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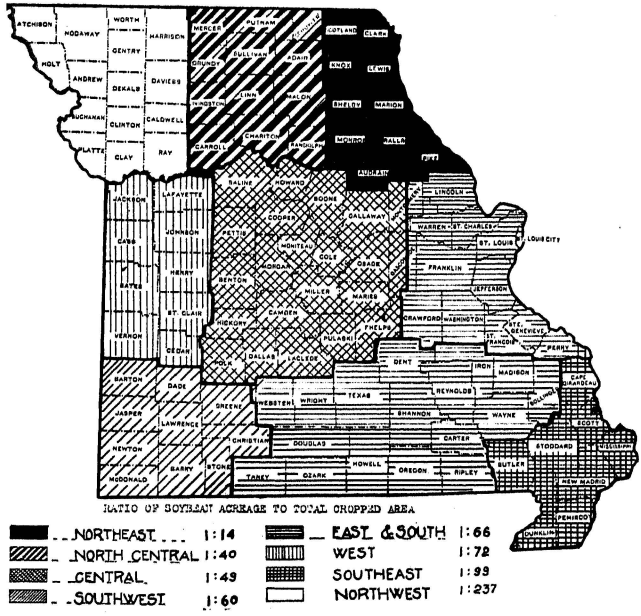
Time of Harvesting Soybeans

In Relation to Soil Improvement and Protein Content of the Hay



Map showing the ratio of soybean acreage to total cropped area in different sections of Missouri.

COLUMBIA, MISSOURI
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Time of Harvesting Soybeans

In Relation to Soil Improvement and Protein Content of the Hay

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The recent increase in the soybean acreage in Missouri, the possible future increase, and the irregularity in times of harvest indicate the necessity of knowing something about the yield and composition of soybeans at different stages of growth as a means of determining the proper time to harvest soybeans for maximum results in terms of hay, seed, and soil improvement.

USE OF CROP INFLUENCES HARVEST

There are various conditions which influence the value of soybeans to the farmer. When they are grown for hay it is not only desirable to have a large yield but to have a hay which contains a maximum amount of protein. The dairyman, or other livestock farmer, is interested in having a high protein hay that is palatable and easily digested. It is well known that as a plant becomes older it increases quite rapidly in crude fiber but the percentage of protein becomes less. This causes a widening of the nutritive ratio which has been shown to decrease the digestibility of the feed.

The man who grows soybeans for seed is naturally interested in securing a large seed yield and at the same time, he is concerned as to the influence of the crop on the soil. When a crop of soybeans is harvested for seed, most of the leaves are left in the field. The use of the newly designed harvesters for soybeans will insure the return to the soil of all the plant parts except the seed. It is important, therefore, to know how much nitrogen is returned to the soil by this method of handling.

Whether soybeans are grown for hay, or for seed does not lessen the significance of this crop as a help in maintaining the productivity of the soil. The growers of soybeans must, therefore, be concerned with returning to the soil as much of the nitrogen gathered from the air as is economically possible. When hay is produced and fed and when the manure is properly preserved and spread on the land about 70 per cent of the nitrogen contained in the hay is thereby returned. Little, however, has been said regarding the amount of nitrogen returned in the leaves and stems when the crop is harvested for seed.

With the above considerations in mind, observations were made on the rate, date, and method of seeding, stage of maturity at the time of

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cutting and the relative weight and nitrogen content of the roots, leaves, stems, and pods of the soybean crop.

From the data thus secured, it was possible to determine the amount and location of the nitrogen or protein in the soybean hay harvested at different stages of maturity. This is highly important in livestock feeding. The data make it possible to determine the best time to cut soybeans for hay from the standpoint of total yield, total protein, the distribution of protein in the plant, and the comparative value of the different parts of the plant. Data were also furnished for calculating the amount of nitrogen returned to the soil when a crop of soybeans is turned under for green manuring, cut for hay with varying amounts of leaf loss, or harvested for seed with almost a total loss of leaves.

FORMER INVESTIGATIONS

Some information on this question has been given by Stemple[1] of West Virginia, who found the protein content and yield of soybeans to vary with the stage of maturity of the crop. Also Willard[2], of Ohio, reported on the yield at different periods, but did not consider the analysis of the crop. Both investigators found a maximum yield of dry matter when the pods were well filled and the leaves were beginning to turn yellow. Piper[3] states that soybeans may be cut for hay at any time from the setting of the seed until the leaves begin to turn yellow, but that the crop is best fitted for hay when the pods are well formed. Erdman[4], of Iowa, found that a maximum percentage of nitrogen was found in the

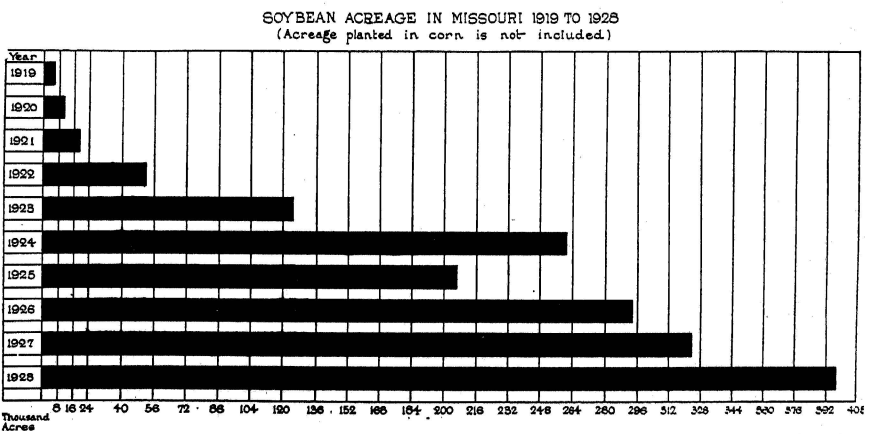

Figure 1.—Increase in soybean acreage in Missouri during the ten year period 1919-1928.

[1]West Virginia Agricultural Experiment Station Bulletin 172.
[2]Journal American Society of Agron. Vol. 17 (1925), pp. 157-168.
[3]Forage Plants and Their Culture. Piper, 1916, pp. 527-528.
[4]Journal of Amer. Soc. of Agronomy. Vol. 21, No. 3, March 1929, pp. 361-366.

soybean tops when the seed was mature, but he gives no data on the yield or location of the nitrogen in the tops, or the per cent of leaves dropped.

METHODS OF PRESENT INVESTIGATION

The investigations herein reported include the results of four years work with soybeans grown on two different types of soil. In 1925 and 1926, the soybeans were grown on a soil of medium fertility well supplied with lime. This soil was of the type known as Shelby loam which is common in North Central Missouri. In 1927 and 1928, the soil used was less fertile and much more leached, having a rather tight subsoil approaching that of the Putnam silt loam, a soil type which is found so extensively in Northeast Missouri. This soil is very deficient in lime in both surface and subsoil, requiring the equivalent of 7,000 pounds of finely ground limestone to correct the acidity of the surface seven inches.

These two soil types represent a large acreage of land which is cropped extensively to soybeans (See Figure 1 and Table 1). The results secured on these soils should be readily applicable to these and probably to many other soils of the state, including the regions where the largest acreage of soybeans is grown.

Virginia soybeans were planted in rows at different rates and cultivated in 1925 and 1926. In 1927 and 1928 the same variety of soybeans was planted both in rows and drilled solid in order to compare the two methods for yield and analysis of the hay. It was realized that there would perhaps be a difference in the results secured with different varieties but the Virginia variety was selected because it is grown more extensively in Missouri than is any other variety. Results secured from this variety should furnish practical information for a large number of

TABLE 1.—SOYBEAN ACREAGE COMPARED WITH THE TOTAL CROP ACREAGE IN MISSOURI BY DISTRICTS—1927.

District*	Total Cultivated Crop—Acres	Total Soybean Acres	Ratio of Soybean Acreage to Total Cropped Area
Northwest	2,431,039	10,712	1 : 236
North Central	1,932,748	47,828	1 : 40
Northeast	1,609,244	119,265	1 : 14
West	1,797,469	25,121	1 : 72
Central	2,365,792	48,585	1 : 49
East	1,407,282	21,775	1 : 65
Southwest	1,316,349	21,784	1 : 60
South Central	1,149,605	17,497	1 : 66
Southeast	1,291,387	13,000	1 : 99
Total	15,300,909	325,567	1 : 47

*The locations of these districts are shown on paeg 1. Data were secured from Farm Census reports by E. A. Logan and Jewell Mayes.

soybean producers throughout the state.

Measurements were taken of the height of plants and counts were made of the number of nodules. The entire harvest was divided into four parts, namely, leaves (including leaf petioles), stems, pods (seed included), and roots. Careful weights were taken of all parts. Nitrogen determinations were made of all the samples.

Methods of 1925.—In 1925 the soybeans were planted on June 14, in rows 2 feet apart, at the rate of 30 pounds of seed per acre. An excellent stand was secured and after six weeks the beans hid the ground almost completely. A dry period in the latter part of August hastened the maturity of the crop and caused the leaves to drop rapidly.

The first plants were harvested July 17, when the crop was 33 days old. Seven harvests of exactly 50 plants each, at intervals of two weeks, were taken. Care was taken to remove all the roots. A trench was dug on each side of the row and water was used to help remove the finer roots. Harvests of hay showed that the largest yield was secured on September 1, so that the weight of hay for that date was taken to represent a 100% crop and the other yields were expressed in relation to it.

Methods of 1926.—The same field used in 1925 was planted to soybeans on May 13, 1926. They were planted in rows 3 feet 6 inches apart and at the rate of 15 pounds per acre. The size of the plants and the yield of seed were greater than for 1925.

The spring was quite cold and the first harvest was taken June 30, when the plants were 48 days old. Fifty plants were harvested, as in 1925, at two week intervals, and the methods used in harvesting were the same except that the roots were dug instead of washed from the soil. Preliminary trials showed that more than 90 per cent of the roots could be removed without water. There was an abundance of moisture throughout the season, which encouraged a very rank growth. The leaves did not begin to drop until much later in the season than was the case for 1925. The maximum yield of hay was harvested on September 5.

Methods of 1927.—The soybeans studied in 1927 were grown on the Experiment Station field as a catch crop following wheat. They were planted on July 15, in rows 3 feet 6 inches apart on half of the plot, and were drilled solid (8-inch row) with a grain drill on the other half.

An excellent stand was secured. A light frost made it necessary to harvest the beans on September 23. A total of from 50 to 70 plants were harvested from 15 to 20 places taken at random on each plot. The nodules were counted and the plants divided, as in previous years, into leaves, stems, pods, and roots. Yields were secured by harvesting the entire plots. The late seeding gave a short growing season and a rather light yield.

Since the use of soybeans as a catch crop often delays planting until the middle of July, it was desirable to learn whether the relative yields of protein in the various parts of the plant were influenced by planting in rows or planting solid. It seemed probable that the method of planting would influence the rate of growth and maturity of the crop and so determine the most desirable time of harvest.

Methods of 1928.—The field which grew the catch crop of soybeans in 1927 was planted to soybeans again on May 15, 1928. Half the plot was planted in rows 3 feet 6 inches apart, to be cultivated, while the other half was drilled solid. This afforded an opportunity of making the same measurements on soybeans grown as a main crop, as were made on the catch crop the previous year.

In addition to the above field, a plot of land which had remained without crop until August was planted to soybeans on August 3. Half of the plot was planted in rows 3 feet 6 inches apart and the other half was drilled solid. Data secured from these soybeans should prove valuable in showing how soybeans can best be used as a substitute crop to replace earlier crops which may have been destroyed by insects, floods, hail, etc.

The season was quite favorable and an excellent growth was secured for both the main crop and the substitute crop. Two harvests of the main crop were made at different dates and three harvests were taken of the substitute crop, so that the relative yields and analyses for the different dates might be compared.

INDEX FOR TIME OF HARVEST

The choice of a particular crop characteristic naturally suggests itself as the simplest index of the proper time for harvest. A certain stage of bloom in the case of timothy and clover and the development of shoots in alfalfa are illustrations of an index of proper time for harvest in the case of these crops. For soybeans, various crop conditions or characters might be considered, such as the following: (1) The age or the time after planting. (2) The height of the plant. (3) The time after blooming. (4) The yellowing of the leaves. (5) The dropping of the leaves. (6) The degree to which the pods are filled. (7) The brown color of the pods.

In addition to the consideration of the above characters, the following questions suggest themselves: Will soybeans that are planted early show the same signs of maturity as those planted later? Does the method of planting alter the time of maturity of the soybeans? Will soybeans drilled solid show the same crop characteristics as when planted in rows? Will the yield and protein content of the different parts of the soybean plants grown in rows differ widely from that in the same parts of plants

drilled solid? How much nitrogen can be returned to the soil to serve for soil improvement—(a) when the crop is harvested for hay? (b) when the crop is harvested for seed?

Result of Investigation

The livestock raiser is concerned not only with the yield of hay but also with its quality and composition. Since he is more accustomed to speaking of the "crude protein content" than of the "nitrogen content", all nitrogen analyses have been multiplied by 6.25 to give the crude protein content of the moisture-free soybean hay for the different harvests. It is, however, not only important to know the protein content of the hay, but also desirable to know how much of this protein is in the leaves, in the stems, in the pods, or in the roots of the plants when the soybeans are cut for hay. It is evident that protein found in the green leaves is more easily utilized by livestock than is that located in the woody stems.

Nitrogen determinations made on the various parts of the plants harvested at different stages of maturity made it possible to measure the total yield of nitrogen and protein for the different harvests and also to determine the location of this protein. The nodule counts and root analyses gave an index of the nitrogen fixing activities of the crop.

From these analyses and studies, the amount of nitrogen returned to the soil when soybeans were harvested at different times and in different ways was calculated. Since the length of growing season for soybeans grown as a catch or substitute crop is often shortened by frost, the crops in 1927 and 1928 furnish a means of comparing the yield, stage of maturity, and protein content of beans planted in rows and those drilled solid during the short growing period, following the middle of July or the first of August.

CHANGES IN CROP WITH AGE

The data regarding the age, height, stage of maturity, weight, and number of nodules for the soybeans grown in 1925, and 1926, are shown in Table 2. Since the harvests for both years were taken at intervals of two weeks and since the seasons were quite different for the two years, the harvests for 1925 do not always correspond with those for 1926 as regards stage of maturity. A study of this table shows that a maximum weight was reached much earlier in 1925 than in 1926. In both years, however, when all the leaves were saved, a maximum weight was reached soon after the pods were set but before they were well filled. The plants had attained a maximum height at this time but the 1925 crop reached this stage on August 28, or only 75 days after planting, while the 1926 crop had the heaviest weight on September 8, or 118 days after planting.

TABLE 2.—YIELDS OF SOYBEANS AT DIFFERENT STAGES OF MATURITY, 1925 AND 1926

Date harvested	Stage of maturity	Age Days	Height Inches	Weight 50 plants in grams	Acre yield hay in pounds	Average nodules per plant
1925						
July 17	Rapid growing period	33	15	97.05	333.6	1.6
July 31	Rapid growing period, starting to bloom	47	24	276.05	914.4	13.6
Aug. 14	Fall bloom stage, few pods formed	61	32	650.00	2234.4	17.7
Aug. 28	Pods formed, ⅕ filled	75	59	1163.50	4000.0	18.2
Sept. 11	Pods filled, leaves yellowing, ⅖ dropped*	89	62	955.00	*3248.0	18.7
Sept. 27	Pods ripening, ⅗ leaves dropped*	103	61	906.70	*3114.4	7.3
Oct, 10	Pods mature, 84% leaves dropped*	117	63	955.70	*3285.2	5.4
1926						
June 30	Growing very slowly	48	15	126.2	178.5	18
July 14	Rapid growing period	62	27	438.3	619.5	20
July 28	Rapid growing period, started to bloom	76	42	1228.1	1735.5	24
Aug. 11	Full boom stage, many pods formed	90	56	1594.8	2255.5	28
Aqg. 25	Pods formed, few filled*	104	70	2700.0	3832.5	27
Sept. 8	Pods ¾ filled, ⅕ leaves had dropped*	118	68	3525.5	*5000.0	18
Sept. 22	Pods ripening, leaves yellowing, ½ had dropped*	132	67	3192.2	*4514.5	10
Oct. 6	Pods mature, ¾ leaves dropped*	146	68	3108.9	*4396.5	7

*Screens were used and the leaves that fell were collected and were counted in the yield. Had these leaves not been saved the later yields would have been very materially decreased. (This is shown in Table IV, where the weight of dropped leaves is given.)

Table 3 gives the data regarding the age, yield, and per cent of weight in different parts of plants harvested from soybeans grown in 1927 and 1928. The data show that soybeans drilled solid yielded more hay than when planted in rows and cultivated. (This is in accord with the findings of the Department of Field Crops of this Station at Columbia, although on very thin soils, or on soils badly infested with weeds, drilled beans are seldom recommended. In such cases they must be handled carefully to prevent weeds and grass from interfering with their growth). The percentage of increase in the yield depended upon the length of growing season allowed the beans. In the case of the catch crop of 1927, the drilled beans yielded 50.6 per cent more hay than did the beans planted in rows and cultivated. The harvests for 1928 show that the increase in yield in the case of the drilled soybeans harvested October 10 was 138.7 per cent, while the increase was reduced to 98.6 per cent when the harvest was delayed until October 19.

The first harvest of the main crop was made on September 3, at which time the soybeans drilled solid yielded 61.1 per cent more hay than did the cultivated soybeans. When the harvest, however, was delayed until September 12, the increase in yield was reduced to 44.1 per cent. It will be noted also that during this period there was a rapid decrease in the weight of leaves, accompanied by a corresponding increase in the weight of pods.

AGE IN DAYS POOR INDEX OF HARVEST TIME

The data for the 4 years indicate that from the standpoint of yield age of plant in days after planting is a very poor index for the harvest. The data show that soybeans planted early in the spring grow much slower at the start and require a longer period to mature than when planted later in the season.

HEIGHT OF PLANTS NOT A GOOD INDEX OF YIELD

The data show that height of plants is not an index to either yield or maturity. It is true that the plants reached a maximum height by the time they showed the greatest yield. It will be noted however that even though the soybean plants grown in 1926 were only slightly taller than those produced in 1925, the actual weight of the plants was found to be very much greater. The soybean grown as a substitute crop in 1928 showed a height of only 18.5 inches and a yield of 3540 pounds for the plot drilled solid, but those grown as a main crop the same year reached a height of 61 inches with a yield of 5222 pounds. Thus it will be noted that although the height of the soybeans grown as a main crop was 3.3 times greater than for the substitute crop, the yield was only 47 per cent larger.

TABLE 3.—YIELD* OF SOYBEANS DRILLED SOLID VS. SOYBEANS IN ROWS—1927-1928

Method of Planting	Date Harvested	Age in Days	Height in Inches	Yield of Hay lbs. per Acre	Per cent Weight in Roots	Per cent of Weight of Hay in:			Increase for Drilling	
						Leaves	Stems	Pods	Weight	Percentage
Catch Crop—Planted July 15, 1927										
Rows 3 feet 6 inches cultivated	Sept. 27, 1927	69	14.	1486	17.9	51.6	35.2	13.2	----	----
Drilled in 8 inch rows	Sept. 27, 1927	69	13.5	2238	18.9	44.8	31.3	23.9	752	50.6
Substitute Crop—Planted August 3, 1928—1st Harvest										
Rows 3 feet 6 inches cultivated	Oct. 10, 1928	61	18.5	1500	7.10	49.1	23.7	27.2	----	----
Drilled in 8 inch rows	Oct. 10, 1928	61	17.0	3580	10.9	47.9	34.5	17.6	2080	138.7
2nd Harvest										
Rows 3 feet 6 inches cultivated	Oct. 13, 1928	64	19.3	1545	6.7	44.0	24.1	31.9	----	----
Drilled in 8 inch rows	Oct. 13, 1928	64	17.4	3593	10.4	35.5	30.4	34.1	2048	32.5
3rd Harvest										
Rows 3 feet 6 inches cultivated	Oct. 19, 1928	70	20.5	1784	6.1	40.0	23.2	36.8	----	----
Drilled in 8 inch rows	Oct. 19, 1928	70	18.5	3543	9.6	36.2†	32.0	31.8	1759	98.6
Main Crop—Planted May 15, 1928—1st Harvest—Pods formed, few filled										
Rows 3 feet 6 inches cultivated	Sept. 3, 1928	111	64	3080	8.8	40.5	30.6	28.9	----	----
Drilled in 8 inch rows	Sept. 3, 1928	111	60	4961	12.5	40.3	35.5	24.2	1881	61.1
2nd Harvest—Pods ⅗ filled—Leaves dropping rapidly										
Rows 3 feet 6 inches cultivated	Sept. 12, 1928	120	66	3623	7.4	32.8	29.8	37.3	----	----
Drilled in 8 inch rows	Sept. 12, 1928	120	61	5222	12.2	31.8‡	33.2	34.9	1599	44.1

*All weights are expressed on a moisture free basis. By adding about ⅕ to the weight given, the yield of field cured hay will be secured
†About 10% of the leaves had dropped in case of the drilled soybeans. (Oct. 19, 1928).
‡About 15% of the leaves had dropped from drilled soybeans. (Sept. 12, 1928)

TIME AFTER BLOOMING ONLY FAIR INDICATION OF MATURITY AND YIELD

As is shown in Table 4, the maximum yield was secured on August 28 for 1925, or 28 days after the first bloom occurred. In 1926 the maximum yield was not secured until September 8, which was 42 days after the appearance of the first bloom. For 1925 the pods were ripening by September 27, which was 85 days after blooming, while in 1926 the pods ripened about the same date but the time after blooming was but 56 days.

In case of the catch crop that was drilled solid in 1927 the beans were fairly mature, although the crop was harvested 69 days after planting or only about 23 days after the first bloom appeared. Both the drilled soybeans and those planted in rows and cultivated in 1928 matured seed in 70 days, which was but 28 days after blooming. These data show that the time after blooming can not be used as a guide for harvesting soybeans for either seed or for hay.

POD MATURITY A GOOD INDEX FOR HARVEST

The data contained in Tables 5 and 6 show that in 1925 the heaviest weight was found when the pods were formed but few of them filled. Moreover, at this time the hay contained the greatest amount of protein. Of the total amount of protein contained in the entire plant at this date, 63 per cent was found in the leaves. One ton of hay harvested at this time contained 323 pounds of protein, 212.5 pounds, or 63 per cent, of which was located in the leaves. By delaying the harvest until the pods were well filled, the amount of protein for each ton of hay was reduced 12 pounds, even when the leaves that dropped were saved.* At this time only 83 pounds, or 27 per cent of the total protein was found in the leaves remaining on the plant.

In 1926 the largest yield of protein, together with the greatest weight of hay, was secured when the pods were about three-fourths filled and after one-fifth of the leaves had dropped. From careful daily observations made on the field, it was concluded that a better quality hay, with just as large a yield, could have been harvested about a week earlier or when a smaller percentage of the pods had filled. By delaying the harvest, the stems became woody and less palatable. Much of the protein was translocated from the leaves and stems into the pods and a considerable amount of the nitrogen or protein was lost in the leaves that dropped.

The yellowing or dropping of leaves depends much on seasonal conditions and does not, therefore, serve as a safe index for harvesting

*While care was taken to collect the fallen leaves, it was impossible to save all of them, especially during rainy and windy weather.

TABLE 4.—PER CENT OF HARVEST FOUND IN ROOTS, LEAVES, STEMS AND PODS AT DIFFERENT HARVESTS IN 1925 AND 1926

Date Harvested	Stage of Maturity (1925)	Age Days	Yield of Hay lbs. per Acre	Per cent weight in Roots	Per cent of Weight of Tops in			
					Leaves		Stems	Pods
					On Plant	On Ground		
1925								
July 17	Rapid growing period	33	333.6	12.4	64.2	----	23.4	----
July 31	Rapid growing period, starting to bloom	47	914.4	12.9	60.2	----	26.9	----
Aug. 14	Full bloom stage, few pods forming	61	2234.4	10.6	60.0	----	29.4	----
Aug. 28	Pods formed, 1/5 filled	75	4000,0	6.6	52.2	----	34.8	6.4
Sept. 11	Pods filled, leaves yellowing, 2/5 dropped*	89	3248.0	7.8	22.4	20.0	32.9	16.9
Sept. 27	Pods ripening, brown, 3/5 leaves dropped*	103	3114.0	6.7	16.6	24.8	31.0	20.9
Oct. 10	Pods mature, 84% leaves dropped*	117	3285.0	7.0	6.8	24.9	30.2	28.1
1926								
June 30	Growing very slowly	48	178.5	10.6	69.3	----	20.1	----
July 14	Rapid growing period	62	619.5	9.7	62.5	----	27.8	----
July 28	Rapid growing period, starting to bloom	76	1735.5	6.6	55.9	----	35.5	----
Aug. 11	Full bloom stage, many pods formed	90	2255.5	7.6	49.2	----	38.0	15.2
Aug. 25	Pods formed, few filled	104	3832.5	6.8	34.0	----	35.0	24.2
Sept. 8	Pods 3/4 filled, 1/5 leaves dropped*	118	5000.0	4.6	25.8	8.3	25.0	36.3
Sept. 22	Pods ripening brown, leaves yellowing, 1/2 dropped*	132	4514.5	4.8	12.8	13.9	28.8	39.7
Oct. 6	Pods mature, 3/4 leaves dropped*	146	4396.5	5.0	6.9	19.6	29.1	39.4

*Care was taken to collect all leaves that dropped. Leaves dropped rapidly after pods were filled.

TABLE 5.—TOTAL AMOUNT OF NITROGEN AND PROTEIN PER ACRE AND PERCENTAGE OF TOTAL PROTEIN FOUND IN ROOTS, LEAVES, STEMS AND PODS AT DIFFERENT HARVESTS IN 1925 AND 1926

Date Harvested	Stage of Maturity	Age Days	Yield of N. in Tops lbs. per Acre	*Yield of Prot. in Tops lbs. per Acre	Percentage of Total Protein in				
					Roots	Leaves		Stems	Pods
						On Plant	On Ground		
1925									
July 17	Rapid growing period	33	13.52	54.5	3.7	81.9	----	14.4	----
July 31	Rapid growing period, starting to bloom	47	33.07	206.2	6.0	78.5	----	15.5	----
Aug. 14	Full bloom stage, few pods forming	61	60.50	378.0	5.5	77.1	----	17.4	----
Aug. 28	Pods formed, ⅛ pods filled	75	102.54	643.0	4.4	63.1	----	24.1	8.4
Sept. 11	Pods filled, leaves yellowing, ⅜ dropped	89	78.18	487.0	4.7	26.7	17.9	21.5	29.2
Sept. 27	Pods ripening, brown, ⅓ leaves dropped	103	78.30	489.0	2.9	15.6	21.8	20.5	39.2
Oct. 10	Pods mature, 84% leaves dropped	117	84.05	528.0	2.6	6.3	17.6	12.3	61.2
1926									
June 30	Growing very slowly	48	7.50	46.8	4.8	83.2	----	12.0	----
July 14	Rapid growing period	62	23.60	148.3	5.3	79.9	----	15.8	----
July 28	Rapid growing period, starting to bloom	76	56.05	350.1	2.6	80.8	----	16.6	----
Aug. 11	Full bloom stage, many pods formed	90	58.4	364.6	2.8	66.7	----	23.0	7.5
Aug. 25	Pods formed, few filled	104	111.2	697.0	2.5	42.6	----	18.6	36.3
Sept. 8	Pods ¾ filled, ⅓ leaves dropped	118	153.5	960.2	1.5	25.3	4.0	10.7	58.5
Sept. 22	Pods ripening, brown, leaves yellowing, ½ leaves dropped	132	131.0	818.7	1.6	10.0	11.0	9.9	67.5
Oct. 6	Pods mature, ¾ leaves dropped	146	124.5	778.0	1.6	5.5	10.1	12.7	70.1

*Nitrogen was expressed as protein by multiplying by the factor 6.25.

TABLE 6A.—OVEN DRY YIELD, PER CENT AND AMOUNT OF NITROGEN AND PROTEIN PER TON AND PER ACRE, IN SOYBEANS HARVESTED AT TWO WEEK INTERVALS—1925

Date and Age of Soybeans	Part of Plant	Yield per Acre—lbs.	Nitrogen			Protein		
			Percentage	Lbs. per Ton	Lbs. per Acre	Percentage	Lbs. per Ton	Lbs. per Acre
July 17	Leaves	244.53	4.67	68.46	11.42	29.19	427.9	41.6
33 days	Stems	89.07	2.26	12.06	2.11	14.12	75.4	12.9
	Pods	-----	-----	-----	-----	-----	-----	-----
	Total Tops	333.6	4.03	80.52	13.52	25.17	503.3	54.5
July 31	Leaves	641.85	4.34	59.98	27.86	27.13	374.2	174.2
47 days	Stems	272.55	1.91	11.80	5.21	11.94	74.5	32.0
	Pods	-----	-----	-----	-----	-----	-----	-----
	Total Tops	914.4	3.59	71.78	33.07	22.44	448.7	206.2
August 14	Leaves	1499.28	3.29	44.13	49.35	20.56	276.6	308.4
61 days	Stems	735.12	1.51	9.95	11.15	9.44	62.5	69.6
	Pods	-----	-----	-----	-----	-----	-----	-----
	Total Tops	2234.4	2.70	54.08	60.50	16.96	339.10	378.0
August 28	Leaves	2236.0	3.04	34.01	67.50	19.00	212.5	424.0
75 days	Stems	1490.4	1.74	12.98	25.64	10.88	82.2	160.4
	Pods	273.6	3.37	4.56	9.40	21.06	28.3	58.6
	Total Tops	4000.0	2.58	51.55	102.54	16.15	323.0	643.0
September 11	Leaves on Plant	789.26	2.76	13.61	21.80	17.25	85.10	136.4
89 days	Leaves dropped	704.82	2.1	9.10	14.80	13.10	56.6	92.6
	Stems	1159.54	1.52	10.85	17.63	9.50	68.4	109.0
	Pods	594.38	4.03	16.16	23.95	25.19	101.1	149.0
	Total Tops	3248.0	2.49	49.72	78.18	15.56	311.2	487.0
September 27	Leaves on Plant	535.61	2.22	7.92	12.05	13.88	49.5	75.4
105 days	Leaves dropped	800.30	2.05	10.87	16.45	12.81	68.0	103.0
	Stems	1002.71	1.55	10.30	15.65	9.69	64.5	98.0
	Pods	775.38	4.41	19.69	34.15	27.56	123.1	212.6
	Total Tops	3114.0	2.44	48.78	78.30	15.26	305.1	489.0
October 10	Leaves on Plant	230.13	2.45	2.45	5.66	15.31	15.3	35.5
117 days	Leaves dropped	882.38	1.68	9.60	14.84	10.50	60.0	93.0
	Stems	1067.63	0.97	6.39	10.30	6.06	40.0	64.3
	Pods	1104.86	4.81	31.55	53.25	30.06	197.2	335.2
	Total Tops	3285.0	2.5	49.99	84.05	15.63	312.5	528.0

(By adding about one-eighth to the weights given, the yield of field cured hay may be secured)

TABLE 6B.—OVEN DRY YIELD, PER CENT AND AMOUNT OF NITROGEN AND PROTEIN PER TON AND PER ACRE, IN SOYBEANS HARVESTED AT TWO WEEK INTERVALS—1926

Date and Age of Soybeans	Part of Plant	Yield per Acre—lbs	Nitrogen			Protein		
			Percentage	Lbs. per Ton	Lbs. per Acre	Percentage	Lbs. per Ton	Lbs. per Acre
June 30 48 days	Leaves	138.5	4.74	68.5	6.55	29.6	428.0	41.0
	Stems	40.0	2.34	12.5	0.95	14.6	78.2	5.8
	Pods	------	----	----	----	----	----	----
	Total	178.5	4.05	81.0	7.50	25.10	506.2	46.8
July 14 62 days	Leaves	428.0	4.34	60.0	19.85	27.2	376.6	124.9
	Stems	191.5	1.95	11.8	3.75	12.4	74.4	23.4
	Pods	----	----	----	----	----	----	----
	Total	619.5	3.59	71.8	23.60	22.55	451.0	148.3
July 28 76 days	Leaves	1040.0	4.43	53.6	46.55	27.7	335.0	291.0
	Stems	695.5	1.36	10.8	9.5	8.5	67.5	59.1
	Pods	----	----	----	----	----	----	----
	Total	1735.5	3.22	64.4	56.05	20.13	402.5	350.1
August 11 90 days	Leaves	1200.4	3.31	35.4	39.80	20.7	224.0	248.5
	Stems	929.0	1.48	12.4	13.70	9.5	77.5	85.5
	Pods	126.1	3.44	3.9	4.90	21.5	24.4	30.6
	Total	2255.5	2.59	51.7	58.4	16.3	325.9	364.6
August 25 104 days	Leaves	1400.0	3.32	24.2	49.8	20.8	151.2	250.0
	Stems	1440.5	1.46	11.0	21.6	9.1	68.7	312.0
	Pods	992.5	3.96	22.8	39.8	24.7	142.5	135.0
	Total	3832.5	2.90	58.0	111.2	18.12	362.4	697.0

September 8 118 days	Leaves on Plant	1351.0	2.91	15.8	39.5	18.2	98.7	244.9
	Leaves dropped	435.0	1.42	2.4	6.2	8.9	15.0	38.8
	Stems	1314.0	1.27	6.7	16.7	7.9	41.9	104.5
	Pods	1900.0	4.78	36.4	91.5	30.0	227.4	572.0
	Total	5000.0	3.07	61.3	153.5	19.15	383.0	960.2
September 22 132 days	Leaves on Plant	622.0	2.2	3.2	12.8	13.7	20.0	80.0
	Leaves dropped	668.0	2.1	8.7	14.0	13.1	54.4	87.5
	Stems	1325.0	0.97	6.1	13.2	6.06	38.2	82.7
	Pods	1898.5	4.83	40.0	91.0	30.1	250.0	568.5
	Total	4513.5	2.90	58.0	131.0	18.13	362.6	818.7
October 6 146 days	Leaves on Plant	316.0	2.2	3.2	6.95	13.7	20.0	43.4
	Leaves dropped	905.0	1.4	5.8	12.70	8.75	36.2	79.3
	Stems	1350.0	1.19	7.4	16.20	7.48	46.2	101.1
	Pods	1824.5	4.85	40.2	88.65	30.15	251.0	554.2
	Total	4395.5	2.83	56.6	124.5	17.67	353.4	778.0

(By adding one-eighth to the weights given, the yield of the field cured hay may be secured)

soybeans for hay. The occurrence of a hot dry period soon after the soybeans have bloomed, may cause the crop to drop many leaves, while if plenty of moisture is available but few leaves will drop before the pods are pretty well filled. In the latter case the yellowing of the leaves will also be delayed. The development of the brown color of the pods serves as a good index for the time of harvesting soybeans for seed.

Based on the data secured on these two crops of soybeans as well as the measurements and observations made for the crops grown in 1927 and 1928, it is concluded that a maximum yield of hay containing the largest amount of nitrogen and protein can be secured by harvesting the beans soon after the pods are well formed and are beginning to fill.

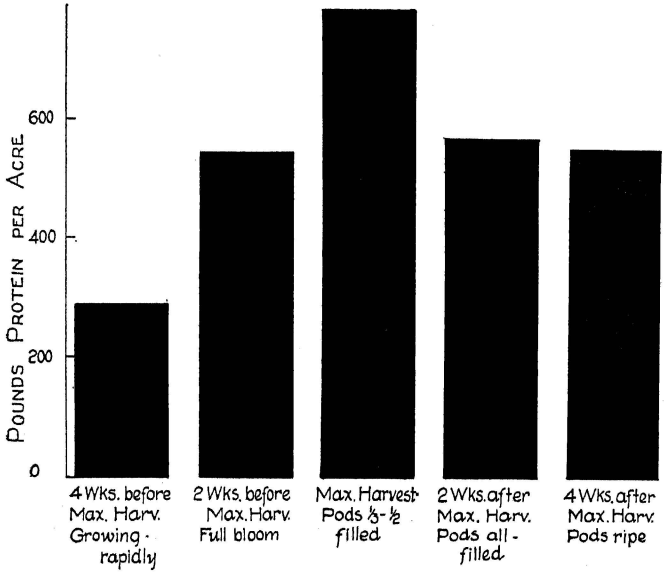

Figure 2.—Total pounds of protein per acre in oven dry soybean hay, harvested at different dates. Note that maximum yield is secured when pods are one-third to one-half filled (2-year average).

This is shown very clearly in Figures 2, 3, and 4. Figure 2, gives the average yield of protein at the various harvest dates for 1925 and 1926. The largest protein yield was secured when the pods were one-third to one-half filled. By harvesting two weeks earlier the yield was reduced 31.2 per cent, while if harvesting was delayed two weeks the yield of protein was 28 per cent lower. The actual concentration of protein in the soybean hay harvested at different periods was found to remain fairly constant when the fallen leaves were deducted. This is shown

by Figure 3, which gives the pounds in a ton of hay harvested at different stages of maturity. The location of this protein within the plant parts, however, was very different as is shown by Figure 4. It will be noted that the amount of protein in the stems remained fairly constant (although the actual weight of stems increased), but that there was a great difference in the amount of protein found in the leaves and pods at the different harvests. The early harvested hay had a high percentage of its protein in the leaves but that harvested late had a low percentage in the pods.

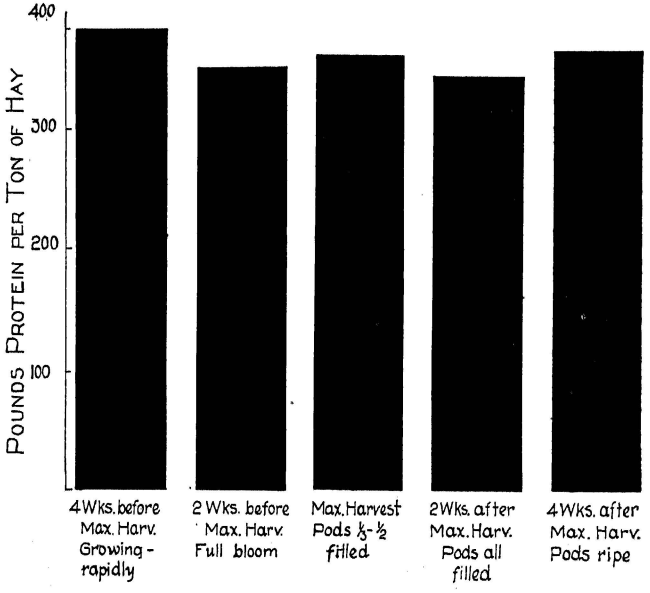

Figure 3.—Concentration of protein in oven dry soybean hay. (Pounds per ton when harvested at different dates).

By harvesting soybeans for hay when the pods are about one-half filled, few leaves will be lost and a maximum yield of protein will be secured. The protein will also be more uniformly distributed throughout the plant rather than concentrated in the pods as is the case when harvesting is delayed. The hay will be more palatable and more easily digested than the later cut hay. It is also much easier to cure soybean hay before the pods are well filled, since the pods lose moisture very slowly and thus delay the curing of the hay.

HOW TIME AND METHOD OF PLANTING INFLUENCE TIME OF HARVEST

It will be noted in Table 7 that the drilled soybeans yielded much more protein than did the soybeans planted in rows. The catch crop grown in 1927 yielded 135 pounds more protein when drilled solid than when planted in rows and cultivated. The increase in protein from the drilled beans over that from the cultivated beans grown in 1928 was more than 250 pounds for the substitute crop and 200 pounds for the main crop. Calculating protein worth 5c per pound, the value of the increase in yield of protein on each acre amounted to $6.75 for the catch crop of 1927, $12.50 for the substitute crop of 1928, and more than $10.00 for the main crop grown the same year. In every case the drilled soybeans matured earlier and could have been harvested at an earlier date than the soybeans planted in rows and cultivated.

Due to the fact that early frost may influence the length of the growing season for soybeans grown as a catch crop, these data suggest that larger yields of hay containing a larger quantity of protein can be secured from soybeans drilled solid than from soybeans planted in rows. This is particularly the case when the soybeans are grown as a catch or substitute crop.

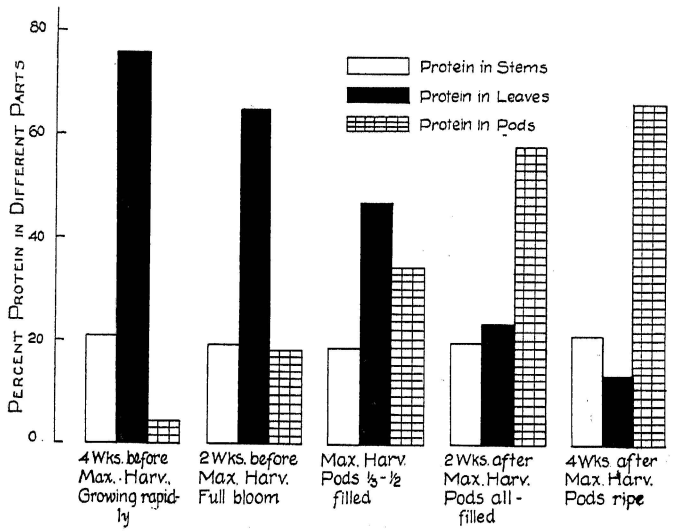

Figure 4.—Relative amount of protein found in the stems, leaves, and pods of soybeans when harvested at two week intervals. Note the inverse relation between protein in leaves and that in pods (2-year average).

TABLE 7.—OVEN DRY YIELD, PER CENT AND AMOUNT OF NITROGEN AND PROTEIN IN SOYBEANS PLANTED IN ROWS VS. SOYBEANS DRILLED SOLID—1927-1928

Date and Age of Soybeans	Method of Planting	Part of Plant	Yield per Acre	Nitrogen		Protein			
				Percentage	Lbs. per Acre	Percentage	Lbs. per Acre	Value*	Lbs. Inc. per Acre for drilling
Crop, 1927									
		Leaves	766	2.9	22.50	18.31	140.3	$7.00	
Sept. 27, 1927	Rows 8 feet 6 inches	Stems	523	1.3	6.90	8.25	43.15	2.16	
69 days old	cultivated	Pods	197	3.28	6.43	20.5	40.18	2.04	
		Roots	266	1.17	2.40	7.3	----	----	
		Total in hay	1486	2.41	35.83	15.1	223.7	$11.20	
		Leaves	1000	2.95	29.60	18.48	185.3	9.25	45.0
Sept. 27, 1927	Drilled in 3 inch rows	Stems	700	1.43	9.92	8.81	61.71	3.09	18.56
69 days old		Pods	538	3.21	17.72	20.9	111.82	5.60	71.64
		Roots	423	1.41	5.83	8.8	----	----	----
		Total in hay	2238	2.81	57.24	16.1	358.8	$17.94	135.1
Substitute Crop,	1928								
		Leaves	738	2.45	17.90	15.3	112.7	8.95	
Oct. 10, 1928	Rows 3 feet 6 inches	Stems	356	2.61	9.31	16.4	58.38	4.65	
61 days old	cultivated	Pods	406	3.32	14.82	22.8	92.79	7.40	
		Roots	106	1.66	1.69	10.0	----	----	
		Total in hay	1500	2.82	42.03	17.6	263.87	$13.20	
		Leaves	1710	2.37	40.62	14.8	253.80	12.69	141.10
Oct. 10, 1928	Drilled in 8 inch rows	Stems	1235	1.93	21.23	10.8	135.38	6.69	75.00
61 days old		Pods	635	3.69	23.30	23.1	145.53	7.28	52.74
		Roots	390	1.48	5.65	9.3	----	----	----
		Total in hay	3580	2.39	85.15	14.9	532.71	$26.66	268.84
		Leaves	680	3.21	21.82	20.13	136.88	6.84	
Oct. 13, 1928	Rows 3 feet 6 inches	Stems	372	2.21	8.23	13.8	51.33	2.56	
64 days old	cultivated	Pods	493	4.02	19.69	25.1	123.74	6.18	
		Roots	107	1.51	1.86	9.44	----	----	
		Total in hay	1545	3.21	49.74	20.1	311.95	$15.58	

Oct. 13, 1928 64 days old	Drilled in 8 inch rows	Leaves	1280	2.59	33.00	16.2	206.71	10.30	69.83
		Stems	1092	1.32	14.51	8.3	90.63	4.53	39.30
		Pods	1221	3.27	43.20	22.0	269.50	13.45	145.76
		Roots	374	1.21	4.54	7.6	----	----	----
		Total in hay	3593	2.09	90.71	15.8	566.84	$28.28	254.89
Oct. 19, 1928 70 days old	Rows 3 feet 6 inches cultivated	Leaves	715	2.9	20.8	18.3	130.58	6.52	
		Stems	415	1.8	7.8	11.8	48.85	2.44	
		Pods	654	3.86	25.5	24.3	159.40	7.97	
		Roots	109	2.3	2.3	12.9	----	----	
		Total in hay	1784	3.03	54.1	18.9	338.83	$16.93	
Oct. 19, 1928 70 days old	Drilled in 8 inch rows	Leaves	1283	2.22	28.3	13.8	177.05	8.85	46.47
		Stems	1140	1.49	16.6	9.3	105.48	5.27	56.63
		Pods	1120	3.60	40.5	22.5	253.55	12.66	93.95
		Roots	340	1.35	4.5	8.44	----	----	----
		Total in hay	3543	2.45	85.4	15.3	535.88	$26.78	197.05
Crop, 1928—Planted May 15									
Sept. 3, 1928 111 days old	Rows 3 feet 6 inches cultivated	Leaves	1250	3.2	40.0	20.0	250.0	12.50	
		Stems	940	1.94	17.8	12.00	113.0	5.65	
		Pods	890	3.73	43.2	23.23	270.0	13.50	
		Roots	275	1.75	4.5	10.19	----	----	
		Total in hay	3080	3.28	101.0	20.5	633.0	$31.65	
Sept. 3, 1928 111 days old	Drilled in 8 inch rows	Leaves	2010	3.08	62.5	19.44	390.8	19.50	140.8
		Stems	1520	1.68	25.6	10.50	160.2	8.00	48.2
		Pods	1431	3.30	46.0	20.06	288.0	14.40	18.0
		Roots	553	1.13	9.8	11.13	----	----	----
		Total in hay	4961	2.70	134.0	16.9	839.0	$41.90	207.0
Sept. 12, 1928 120 days old	Rows 3 feet 6 inches cultivated	Leaves	1195	1.98	23.7	12.36	146.83	7.34	
		Stems	1077	1.03	12.5	7.11	76.68	3.83	
		Pods	1351	3.47	53.5	24.75	335.36	16.76	
		Roots	270	0.95	6.5	5.90	----	----	
		Total in hay	3623	2.53	89.7	15.8	559.0	$27.93	
Sept. 12, 1928 120 days old	Drilled in 8 inch rows	Leaves	1661	1.96	32.8	12.34	204.96	10.24	58.13
		Stems	1735	1.24	21.4	7.74	134.21	6.70	57.53
		Pods	1826	3.93	71.5	24.56	448.71	22.40	113.35
		Roots	637	1.39	8.7	8.7	----	----	----
		Total in hay	5222	2.40	125.7	15.0	783.9	$39.34	224.9

*Protein is valued at an arbitrary figure of 5c per pound which would place the value of hay at $15 per ton. Protein purchased in mill feeds costs about 8 to 10 cents per pound

SOIL IMPROVEMENT BY SOYBEANS GROWN AS A MAIN CROP

When Harvested for Hay.—Investigational work at Pennsylvania, Illinois, and other stations, has shown that, on the average, 25 per cent or less of the nitrogen in the feed is retained by the animal (or secreted in milk) when receiving a balanced ration. The remainder is excreted as solid material and as liquid manure. This indicates that the dairyman or livestock raiser who handles his manure with little loss of nitrogen can return to the soil almost three-fourths of the nitrogen contained in the soybean hay.

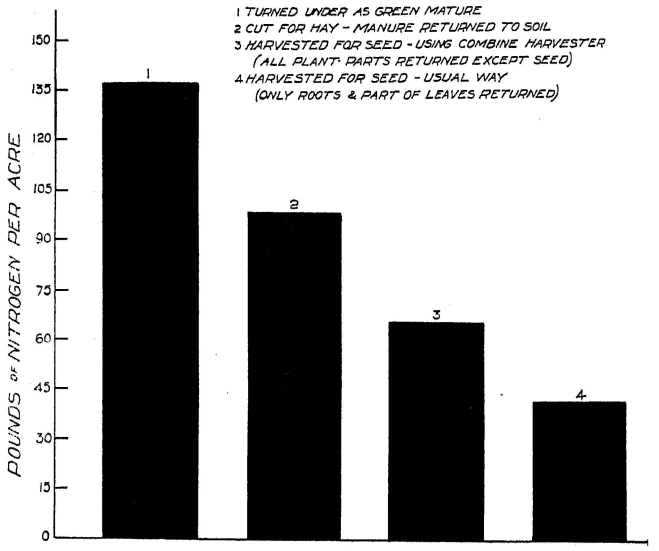

Figure 5.—Graph showing pounds of nitrogen returned to the soil under different methods of utilizing the soybean crop.

The amounts of nitrogen or protein contained in the soybeans harvested in 1925 and 1926, are shown in Tables 5 and 6, and for 1927 and 1928, in Table 7. It will be noted that the largest yield of hay containing the greatest amount of nitrogen for 1925 was harvested on August 28, when the pods were well formed but only one-fifth filled. At that time the hay from one acre contained 102.54 pounds of nitrogen. In 1926 the largest nitrogen harvest was made on September 8, at which time the hay from one acre contained 153.5 pounds of nitrogen.

The main crop of soybeans grown in 1928 carried in the hay 134 pounds of nitrogen when drilled solid, and 101 pounds of nitrogen for the soybeans planted in rows and cultivated. The catch crop of 1927

carried in the hay 57.24 pounds of nitrogen when drilled solid and 35.83 pounds nitrogen when cultivated. Similarly the 1928 substitute crop yielded 90.71 pounds nitrogen in the hay when drilled solid and 49.74 pounds nitrogen when cultivated.

These data and Figure 5 show that the soybean crop furnishes an abundance of nitrogen and valuable protein feed. When this hay is fed to livestock and the manure carefully returned to the soil, significant quantities of nitrogen can be returned. Assuming that all of the nitrogen contained in the dropped leaves would be returned to the soil and that 70 per cent of the nitrogen in the harvested crops would be returned in the manure, there would be a return to the soil of 71.78 pounds in the cultivated crop of 1925, 107.45 pounds in 1926, and 93.8 pounds in 1928. Similarly, the nitrogen returned from the catch crop of 1927 and the substitute crop of 1928 would be 40.07 and 63.49 pounds respectively for the drilled beans and 24.78 and 37.87 pounds for the cultivated beans. The above figures do not include the nitrogen in the soybean roots, which would increase slightly the return of nitrogen to the soil.

Assuming that as much as 50 per cent of the nitrogen in the soybean hay came from the air, the hay contained more than 51 pounds of air nitrogen for the cultivated beans in 1925, 76 pounds in 1926, and slightly less than 47 pounds in 1928. The amount of nitrogen retained by the animals (which is around 25 per cent of that found in the hay) amounts to considerably less than that taken from the air. Thus when the hay is fed to livestock and the manure carefully returned, the equivalent of the nitrogen taken from the soil is returned, together with a considerable portion of that taken from the air.

Recent experiments conducted at this Station with soybeans on different soil types and receiving different soil treatments indicate that the amount of nitrogen secured from the air by well inoculated soybeans may exceed 50 per cent. Under such conditions and assuming no erosion losses, the nitrogen gained by the soil would have been increased.

When Harvested for Seed.—The question is often asked as to how much nitrogen will be returned to the soil when soybeans are harvested for seed. Data in Table 4 show that when soybeans were allowed to mature seed, most of the leaves were dropped before harvest. The nitrogen contained in the leaves under those conditions would, therefore, be returned to the soil. Table 6 shows the amount of nitrogen found in each portion of the plant when harvested at different times. Thus if the soybeans are harvested in such a way that all the leaves are left on the ground, the nitrogen loss will be materially less than if both leaves and seed are removed. By using the newly designed soybean harvesters it is

possible to return not only the leaves but also the stems to the soil. Under these conditions about 51 pounds of nitrogen would have been left on the soil in 1925, 67.5 pounds in 1926 and 63.5 pounds in 1928.

Assuming again that 50 per cent of the nitrogen in the soybean crop came from the air, we find that for 1925, 51.27 pounds were gained in this way, but since approximately the same amount was removed in the seed there was no actual gain of nitrogen by the soil. For 1926 the amount of nitrogen secured from the air was 76.75 pounds while that removed in the seed was 85.96 pounds, showing a loss from the soil of 9.21 pounds. In 1928 there was a maximum removal of 71.5 pounds of nitrogen in the seed, 67 pounds of which came from the air, thus showing a loss of 4.5 pounds from the soil.

From these results it would appear that while there is quite a large supply of available nitrogen left in the soil after growing a crop of soybeans that is harvested for seed there is little increase in the nitrogen supply unless more than 50 per cent of the nitrogen comes from the air.

From the statements made above it is plainly evident that greater soil improvement is secured from the soybean crop when fed to livestock and the manure carefully returned than when the crop is harvested for seed. Although the actual gain of nitrogen may appear small when handled in either way, there is not the removal of nitrogen from the soil that occurs when a non-legume crop is grown. Thus on soils that are not subject to serious erosion and where the crop is turned under as green manure, pastured or fed and the manure returned, the soybean crop can be considered a good soil improving crop.

Soybean May Cause Loss Through Soil Erosion.—Erosion data from this Station show that on land of a very moderate slope the loss of soil and nitrogen has been much greater from continuous soybeans in rows than from corn land where the corn followed clover in the rotation and the clover was followed by wheat in the fall. However, the nitrogen loss from land in continuous soybeans in rows followed by a rye cover crop was approximately 30 pounds per acre while the loss from continuous corn without a cover crop was 40 pounds. With an average annual erosion loss for five years of 30 pounds of nitrogen from each acre of soybean land, it is evident that this becomes a serious handicap to soybeans as a soil building crop. If this crop is to increase the total nitrogen content of the soil, the soybeans must take enough of this element from the air to replace all that lost through the sale of seed, or the losses incidental to feeding the hay to livestock, and in addition the amount lost through erosion.

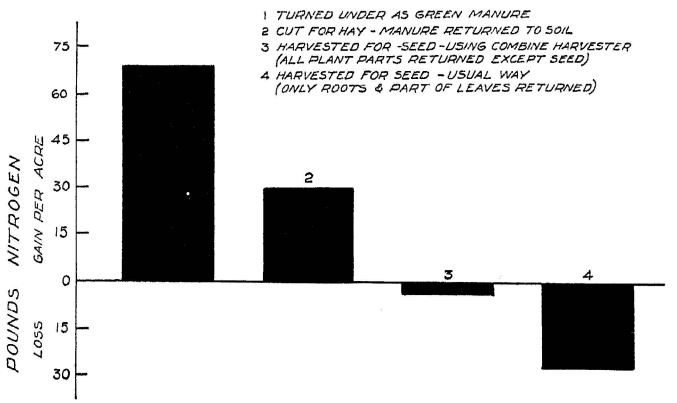

Figure 6.—Graph showing actual gain or loss of soil nitrogen under different systems utilizing the soybean crop.

The figures given above show that the nitrogen gains in growing soybeans may not be large enough to cover these losses on rolling land, especially when the crop is planted in rows and cultivated. This is shown graphically by Figure 6 which gives the nitrogen returned to the soil under different systems of utilizing the soybean crop.

Erosion data for 1928 and to June 1929 show, however, that the soil and nitrogen losses from soybeans drilled solid were only 30 per cent as great as from cultivated soybeans. Under these conditions the nitrogen loss through erosion was only 9 pounds so that the crop could yet be classed as a soil building crop and it would give a good nitrogen "turnover" on land of moderate slope (4 per cent). While further studies of erosion losses under soybeans must be made before the results are entirely reliable it seems quite evident that on rolling land they should be sown solid rather than in rows if they are really to build the soil.

SOIL IMPROVEMENT BY SOYBEANS GROWN AS A CATCH OR SUBSTITUTE CROP

The data in Table 7 indicate that very good yields of hay can be secured (under Central Missouri conditions) from soybeans planted after the middle of July. This hay may be used very profitably as feed for livestock or it may prove profitable for green manuring purposes. This will mean the return to the soil of a good amount of organic matter that is well supplied with nitrogen. This is particularly true where the beans are pastured, or turned under as a green manure.

SUMMARY

The work reported herein covers a period of four years during which time a detailed study was made of the yield and composition of soybeans as influenced by different methods of planting and the stage of maturity of the soybeans when harvested. An attempt was made to determine the conditions of growth which serve as indices of the time of harvest of the Virginia soybeans for the fullest use for hay, for seed, and for soil improvement. The conclusions which seem justified by the results on these respective points are listed below:

1. The age of the crop in days after planting is not a safe index for best time of harvest. Maximum yields were obtained in the first trial in 75 days while for the second trial 120 days gave maximum yields. Early plantings required more time to mature.

2. The height of the plant cannot be used as a measure of the yield since this varies widely with the soil, season, and method of planting, as well as with the variety.

3. The yellowing or dropping of the leaves and the time after blooming depend much on seasonal conditions and do not, therefore, serve as a safe index for harvesting soybeans for hay.

4. The development of the pods together with the degree to which they have been filled serves as the best index for obtaining maximum yields of soybean hay. A maximum hay yield was obtained when the pods were well formed and approximately one-third to one-half filled. Harvesting at this stage gave not only the largest weight, but also the maximum protein in the hay as leaves and minimum as woody stalks. A relatively small amount of the hay occurs as pods at this time.

5. For the most uniform distribution of protein through the hay and for the greatest protein yield, the time of maximum harvest serves best. The delay of harvest beyond maximum yield means: (a) Less weight in leaves, and leaves of lower protein content. (b) A greater number of leaves dropped from the plant. (c) A proportionately higher weight of stems of a lower protein content. (d) An increase in pod and seed development and a corresponding concentration therein, of the plant protein from the leaves and stems.

6. Maximum weight and protein yield were obtained earlier, if the crop was drilled solid than if planted in rows and cultivated. The differences were greater in the case of the catch and substitute crops than in case of the main crops.

7. With reference to soil improvement, soybeans harvested at the time of maximum yield should give very beneficial effects provided the crop is properly utilized. A delay in harvest adds more leaves to the soil, but it does not give increased soil improvement commensurate with the loss in the value of the hay.

8. With proper management soybeans harvested for hay or for seed furnish a good nitrogen "turnover" to the soil. The actual *gain* of nitrogen by the soil, however, is small, even on level land, unless the crop is pastured, used as green manure, or fed and the manure carefully returned. If soybeans are grown on rolling land where erosion is severe an actual loss of nitrogen may result.