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Soybeans for Silage and for Hay

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by T. E. ODLAND

Soybeans and Sudan Grass on a Farm
in Harrison County

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SUMMARY

Corn and soybeans were grown both alone and in various combinations for silage. Soybeans were also grown alone at various rates and dates of planting for hay and in combination with Sudan grass, sorghum, and millet.

Soybeans grown with corn for silage did not increase the total yield per acre over corn grown alone at the same rate of planting.

The soybeans when grown with corn reduced the yield of shelled corn 6 to 8 bushels per acre.

The soybeans made up from 9.3 to 15.4 percent of the total green weight in the various corn and soybean mixtures.

The percentage of protein in the silage was increased when soybeans were grown with the corn.

The yield of protein per acre was increased when soybeans were grown with the corn.

Thie yield of total nutrients per acre was not increased when soybeans were grown with the corn.

The increase in protein per acre due to the growing of soybeans with corn was not large enough to compensate for the extra work necessary in growing the combination.

Soybeans grown alone gave practically the same yield whether grown in cultivated rows or seeded solid.

The soybeans grown alone in cultivated rows produced a crop with a higher protein content than did the soybeans seeded in solid plots.

Soybeans grown with corn did not increase the percentage of protein in the corn; neither did the corn have any influence on the protein content of the soybeans.

Soybeans planted at the rate of 6 and 8 pecks per acre produced a finer quality of hay which was more nearly free from weeds than the seeding of 4 or 5 pecks per acre. There was not much difference in yields.

Soybeans seeded May 20 and later produced hay more nearly free from weeds than when planting was done as early as May 5. Planting as late as June 25 made the crop so late that curing the hay became more difficult.

Soybeans and Sudan grass made the best combination for hay.

*Cultural Experiments With Soybeans for Silage and for Hay**

by T. E. ODLAND†

NO FARM crop introduced into West Virginia has become of such importance in so short a time as have soybeans. In the last ten years the estimated acreage has increased between five and six times.

As this crop has increased in importance and its use has become more general over the state, a number of inquiries in regard to its culture and utilization have, from time to time, been received by the State Agricultural Experiment Station. The purpose of this bulletin is to present the results of experiments conducted under West Virginia conditions and hence applicable to certain of these inquiries. These experiments include a test in which corn and soybeans were grown alone in various ways and in various combinations for silage purposes. In another experiment soybeans were grown alone and in combination with various other crops for hay. The experiments also include tests in which soybeans were sown at various rates and at different dates for hay.

One of the reasons why the soybean has met with much favor over the entire state is its adaptability to a wide range of climatic conditions. No other legume commonly grown in the state is adapted to so wide a range of soil conditions. It will thrive well on any corn soil and does better than most other common legumes on thin, acid soils.

The feeding value of soybean hay has been demonstrated in many feeding trials.[1] When cut at the proper stage and properly cured, soybean hay has about the same feeding value as alfalfa. When mixed with corn, soybeans increase the feeding value of the silage produced on account of their high protein content. The extent of this increase depends upon the proportion of soybeans in the combination.

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[1]W. Va. Agr. Exp. Sta. Bul. 181.

Whether or not it is advisable to grow soybeans and corn together for silage is one of the questions considered in the present report.

Soybeans also make excellent supplementary feed for sheep or hogs when fattened on corn. For this reason soybeans are often planted with corn for hogging down or for pasturing with sheep.

Crop Known for Soil Improvement Qualities

As a soil-improvement crop soybeans are not equal to red clover or alfalfa when the entire crop is removed. This circumstance may be credited in part at least to their less extensive root system. However, if the crop is plowed under or if the hay is fed and the manure is returned to the land, soybeans make an excellent soil-improvement crop. This ability of soybeans to restore fertility has won for the crop a place on the rotation systems of more and more farms.

Soybeans rank as one of the most dependable crops grown in the state. If good seed is sown and the season is an average one, a grower has fair assurance of a good crop. Soybeans are often used as a substitute crop for red clover or alfalfa that has failed to come through the winter satisfactorily. Red clover has been an uncertain crop in recent years and soybeans are finding increasing favor as a substitute for this crop.

Another important characteristic of the soybean is its seed-producing ability. The seed crop is more certain and satisfactory than that of any other legume commonly grown in the state. A yield of 15 to 20 bushels per acre is commonly obtained. Yields as high as 40 bushels per acre have been obtained in very favorable seasons in some of the experiments conducted at this Station. The seed crop also is handled more easily than most forage crops. No special machinery is needed and the seed is easily cleaned.

On many farms the practice of planting soybeans with corn for silage is followed regularly. The combination often is used also for hogging down and for sheep pasture. The argument in favor of growing the combination for silage is that a silage containing a higher percentage of protein is produced and thus the amount of concentrates that it will be necessary to buy will be lessened. This scheme is desirable if the total yield is high enough to repay one for the extra work and inconvenience in growing the combination.

The results of experiments in growing soybeans and corn together for silage have varied considerably. Some investigators have reported in favor of the combination while others have made unfavorable reports.

HISTORICAL REVIEW

At the Connecticut Agricultural Experiment Station[2] an average increase of one ton of silage and 120 pounds of protein per acre was obtained when growing the combination over corn grown alone. The authors concluded that this amount of increase would justify the planting of soybeans and corn together for silage only under certain favorable conditions.

At the Ohio Agricultural Experiment Station[3] no increase in green material per acre was obtained with the combination over corn grown alone. Two varieties of corn were grown. At the University Farm at Columbus, Ohio, the combination gave a slightly higher yield than corn alone.

The Pennsylvania Station[4] did not obtain any increase in total yield of green material per acre from the combination over corn grown alone. In their experiments the authors state that the amount of soybeans in the mixture was not enough appreciably to affect the composition of the silage in four of the six years of the trial.

Stemple[5] in a test covering a period of one year *(1915)* at the West Virginia Agricultural Experiment Station found that a combination of corn and soybeans produced an increase of 1.19 tons of green material per acre over corn alone.

METHODS USED IN WEST VIRGINIA EXPERIMENTS

Experiments with corn and soybeans grown separately and in combination for silage, reported in the present publication, were started in the spring of 1921 and continued over a period of five years. The experiments were conducted at the Agronomy Farm near Morgantown.* In all experiments Leaming corn and Wilson soybeans were used. These were chosen as representative varieties of the two crops for this state.

The corn both alone and when in combination with soybeans was planted in plots consisting of four rows, each 8 rods in length and spaced 3½ feet apart. Only the two central rows of each plot were harvested for yield. Both the corn and soybeans when grown in combination and the corn when grown alone were planted more thickly than the desired stand and then later thinned to the various stands. The soybeans grown alone in rows were planted in plots

[2]Conn. Agr. Exp. Sta. Bul. 133.
[3]Ohio Agr. Exp. Sta. Month. Bul. XII: Nos. 5 and 6, 1922.
[4]Penn. Agr. Exp. Sta. Bul. 187.
[5]W. Va. Agr. Exp. Sta. Bul. 172.

consisting of 4 rows spaced 30 inches apart and 8 rods in length. The two central rows were used for yield determination.

Where soybeans were seeded solid at the rate of six pecks per acre the plots were one drill-width wide, or a little more than 8 feet, and the same length as the other plots. In this case the two outer drill rows on each side of the plot were cut and discarded before harvesting the rest of the plot in order to eliminate border effect as much

Corn and Soybeans grown together for Silage on the Agronomy Farm

as possible. All plots were repeated three times, making four plots of each crop, combination, or method of planting each year.

All plots were harvested at the same time and when the corn had reached the glazed stage. At that time the soybeans had well-developed seeds and some of the leaves were beginning to fall,—somewhat past the best stage to cut soybeans for hay. At harvest time the soybeans were cut and weighed immediately. In the combination crops the corn and soybeans were cut and weighed separately. A sample of about 15 pounds was taken from each plot at the time of cutting in order to determine the moisture content. Chemical analyses* of these samples were made for the years 1923, 1924, and 1925. The sample was weighed at the time it was taken and again after drying. It was dried artificially to a constant weight and then allowed to hang in a shed until it had regained equilibrium with the moisture content of the air. From the weight obtained after such treatment, the air-dry yields per plot were calculated.

*It is recognized that the type of soil will necessarily have much influence on the results obtained in experiments of this nature. The type of soil on which the Agronomy Farm is located is classified as Dekalb silt loam, of medium productivity. This soil type is representative of much of the farm land in West Virginia and therefore the results are applicable to a considerable area of the state.

After the weight of the green material had been obtained the corn was put in shocks and later husked in order to obtain the yield of shelled corn per acre. When the corn was husked a sample was taken on which the moisture content was determined. All grain yields are reported on the basis of 14 percent moisture.

Although the corn when harvested was not as mature as when ordinarily cut for grain, it was all taken at the same time. Consequently the yields may be considered comparable. The yields of shelled corn per acre would probably be somewhat higher if the corn had been left until more fully mature.

EXPERIMENTAL RESULTS

The data obtained for the various combinations, and for each of the crops grown alone, include the total yield per acre of green material, air-dry material, shelled corn, protein, and total nutrients. The percentage of soybeans in the various combinations also was determined.

Yield of Green and Air-dry Material per Acre

The yields obtained both in green and air-dry material per acre are shown in Tables 1 and 2.

The data in these tables show that when corn was grown alone at the rate of 2 stalks per hill the average yield was 7.36 tons of green material per acre; when the corn was grown at the rate of 3 stalks per hill the yield was 8.63 tons or an increase of 1.27 tons per acre in favor of the thicker planting. On the air-dry basis the yield was 0.42 tons per acre in favor of the thicker planting. While this difference in yield was not large, the increase in yield was consistent for every year of the test.

In determining whether differences in average yields between various plots were large enough to be of significance from a mathematical point of view, Student's[6] method was used in comparing the yields of various plots. According to this method the odds are 1,392 to 1 that the difference in air-dry yields obtained between these two rates of planting is significant. Under the conditions of this experiment, therefore, a stand of 3 stalks per hill may be expected to outyield corn planted at the rate of 2 stalks per hill.

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*The author is indebted to T. J. Cochrane, formerly of the agricultural chemistry department, for making the chemical analyses.

[6]Student. "Probable error of a mean." *Biometrika* 6:1-25. 1908.

Table 1.—Yield in Tons of Green Forage per Acre of Corn and Soybeans, Grown Separately and in Various Combinations

Crop or Combination	Method and Rate of Planting	Tons of Green Forage per Acre for the Years 1921 to 1925					Average Yield 1921-25
		1921	1922	1923	1924	1925	
Corn alone	2 stalks	6.97	7.36	8.41	6.91	7.14	7.36
Corn alone	3 stalks	8.44	8.31	9.98	8.43	8.01	8.63
Corn alone	Drilled 7″	9.95	9.61	10.57	9.53	10.44	10.02
Corn alone	Drilled 14″	8.54	8.80	9.72	7.90	9.06	8.80
Corn alone	Drilled 21″	8.02	7.99	9.07	7.05	7.65	7.96
Corn and soybeans	Drilled 7″	9.58	9.21	11.41	9.63	10.75	10.12
Corn and soybeans	2 stalks corn, 1 plant soybeans	7.09	7.09	8.85	6.99	6.21	7.25
Corn and soybeans	2 stalks corn, 2 plants soybeans	7.57	7.87	8.80	7.24	6.77	7.65
Soybeans alone	In rows 30″ apart	5.48	7.34	7.44	8.75	6.88	7.18
Soybeans alone	Solid, 6 pecks per acre	6.13	6.57	7.23	8.36	7.60	7.18

Table 2.—Yield in Tons of Air-dry Forage per Acre of Corn and Soybeans Grown Alone and in Various Combinations

Crop or Combination	Method and Rate of Planting	Tons of Air-dry Forage per Acre for the Years 1921 to 1925					Average Yield 1921-25
		1921	1922	1923	1924	1925	
Corn alone	2 stalks	2.62	2.26	2.29	2.08	2.24	2.30
Corn alone	3 stalks	3.15	2.76	2.80	2.37	2.52	2.72
Corn alone	Drilled 7″	3.65	3.02	2.78	2.63	2.86	2.99
Corn alone	Drilled 14″	3.06	2.77	2.77	2.12	2.84	2.71
Corn alone	Drilled 21″	2.94	2.32	2.33	1.89	2.18	2.33
Corn and soybeans	Drilled 7″	3.33	2.76	2.97	2.64	3.53	3.05
Corn and soybeans	2 stalks corn, 1 plant soybeans	2.47	2.43	2.37	1.95	2.02	2.25
Corn and soybeans	2 stalks corn, 2 plants soybeans	2.66	2.53	2.34	2.02	2.20	2.35
Soybeans alone	In rows 30″ apart	1.96	2.00	2.04	2.62	2.21	2.17
Soybeans alone	Solid, 6 pecks per acre	1.93	2.20	1.95	2.34	2.35	2.15

The yields in both green and air-dry material per acre where 3 and where 2 stalks per hill were grown correspond very closely with the yields obtained on the plots where corn was planted in drills and spaced, respectively, 21 and 14 inches apart in the row. On the air-dry basis the yield of the 2-stalk plots is nearly identical with the average yield of the corn drilled 21 inches apart; the average of the 3-stalk plots is almost identical with the 14-inch planting. The number of stalks per acre is the same when 2 stalks per hill are used as when the corn is drilled at the rate of 1 stalk every 21 inches in the row. The same is true whether 3 stalks per hill are used or whether spacing 14 inches in drilled rows is employed. From these results it apparently makes no difference whether the corn is planted in drills or in hills as long as there are the same number of stalks per acre.

Where the corn was drilled at the rate of 1 stalk every 7 inches in the row the green yield was 10.02 tons and the air-dry yield 2.99 tons per acre. This is an increase over the 14-inch planting of 1.22 tons of green material or 0.28 tons of air-dry material per acre. Although this thicker planting resulted in a higher yield per acre both on the green and on the air-dry basis, the stalks were small and the proportion of grain was very much less than in the thinner plantings.

Corn and Soybeans in Combination

Each year in three series of plots soybeans were planted with the corn in various proportions. In one series corn and soybeans were planted thickly in drilled rows and thinned to a stalk of corn every 7 inches of row with one soybean plant between each two stalks of corn. The average yield for this method of planting was 10.12 tons of green material per acre or 3.05 tons on the air-dry basis, or very nearly the same average yields as for the corn grown alone at the same rate. There was only 0.1 ton difference in average yield per acre on the green basis and 0.06 ton difference on the air-dry basis. The growing of soybeans with the corn at this rate therefore neither increased nor decreased the total yield of silage per acre.

In the plots where one soybean plant was grown in each hill with two stalks of corn the average yield of green material was 7.25 tons per acre; on the air-dry basis the yield was 2.25 tons, or very nearly the same on either basis as when corn was grown alone at the rate of 2 stalks per hill. Where 2 soybean plants were grown in each hill with the corn the yields were 7.65 and 2.35 tons per acre on the green and on the air-dry basis respectively. Here again there is obviously

no difference in total yield per acre whether corn is grown alone or in combination with soybeans.

In all three sets of plots, therefore, where soybeans were grown with corn at various rates, there was neither a significant increase nor decrease in total yield of the combination as compared with corn alone when grown at the same rate as in the combination. If therefore there is any advantage in growing soybeans with corn for silage purposes it must be found in the higher feeding value which might be expected from the combination.

Soybeans Grown Alone

Soybeans were grown alone with two methods of planting. One set of plots was planted in cultivated rows 30 inches apart; the other set was drilled solid at the rate of 6 pecks per acre. The data show that over the 5-year period the average yield for the two methods of seeding was exactly the same on the green-material basis and almost so on the air-dry basis. Similar results were obtained in a single test in 1918 by Stemple.[7] The yield on both the green and the air-dry basis is only a little less than the yield of corn grown at the rate of 2 stalks per hill, or corn grown at this rate in combination with soybeans.

Although there was no difference in yields between the two methods of growing the soybeans there was considerable difference in the crop produced. Where the soybeans were drilled solid the stems were finer than when grown in rows. However, there was always a considerable proportion of weeds in the solid-sown plots, while in the soybeans grown in cultivated rows the weeds were kept out. More seed also was produced in the cultivated rows. The chemical analyses showed that the soybeans grown in rows had the higher protein content.

Proportion of Soybeans to Corn in the Combination Plots

In the plots where the corn and soybeans were grown in combination, each crop was cut and weighed separately in order to find the percentage by weight of each. Table 3 gives the average percentage of soybeans in each of the various mixtures for each year in which they were grown. The figures in this table are based on the green weights. On an air-dry basis the proportion was practically the same.

[7] W. Va. Agr. Exp. Sta. Bul. 172.

The data in this table show that, in the plots where soybeans were planted with corn that had been drilled and thinned so as to have a stalk every 7 inches in the row, the percentage of soybeans in the combined crop ranged from 12.3 percent in 1921 to 23.2 percent in 1923, with an average of 15.4 percent for the 5-year period.

Where one soybean plant was grown in each hill of corn, the percentage of soybeans in the mixture varied from 6.7 percent in 1924 to 11.5 percent in 1921, with an average of 9.3 percent for the period of the experiment.

Table 3.—Percentage by Weight (Green) of Soybeans in the Various Combinations of Corn and Soybeans

Combination and Rate	Percentage of Soybeans in Mixture for the Years 1921 to 1925					Average Percentage of Soybeans in Mixture
	1921	1922	1923	1924	1925	
Corn and soybeans, drilled 7"--	12.3	15.0	23.2	14.0	12.4	15.4
Corn 2, soybeans 1, per hill----	11.5	7.7	11.3	6.7	9.2	9.3
Corn 2, soybeans 2, per hill----	17.7	13.0	18.7	12.0	13.6	15.0

In the plots where 2 soybean plants were grown in each hill the percentage of soybeans in the mixture varied from 12.0 percent in 1924 to 18.7 percent in 1923, with an average of 15 percent.

As these figures indicate, the proportion of soybeans in the mixture varied considerably from year to year. In the two mixtures where soybeans were planted so that there were approximately equal numbers of corn and soybean plants, the soybeans made up approximately 15 percent of the mixture in each case. Where only one soybean plant was used per hill, the proportion of soybeans in the mixture was considerably less.

Yield of Shelled Corn Grown Alone

When soybeans are grown with corn and the corn is cut and husked, there is amost always a reduction in the yield of corn as compared with corn grown alone at the same rate. A number of experiment stations have reported results on such tests. At the Missouri Station[8] a reduction in yield of from 4 to 8 bushels per acre was obtained when soybeans were grown with corn in varying combinations. At the Tennessee Station[9] both cowpeas and soybeans when planted with corn reduced the yield of corn considerably.

In the experiments conducted at the West Virginia Station the yield of shelled corn for each plot was determined both where corn

[8]Mo. Agr. Exp. Sta. Bul. 220.
[9]Tenn. Agr. Exp. Sta. Bul. 137.

was grown alone and where soybeans were grown with the corn. The yields obtained on the various plots are given in Table 4.

The average yield of shelled corn on the plots where corn was grown alone with 2 stalks per hill was 40.5 bushels per acre. Where 3 stalks per hill were grown the yield was 43.5 bushels per acre, or an increase of 3 bushels per acre over the 2-stalk plots. The odds are 16 to 1 that this difference is large enough to be considered significant.

Where the corn was planted in drills and thinned to one stalk every 14 inches the yield was 41.5 bushels per acre; where the stalks were spaced 21 inches the yield was 41.6 bushels. These yields are almost identical. They are one bushel per acre more than was obtained from the 2-stalk plots and 2 bushels per acre less than the 3-stalk plots produced.

Little difference was noted among yields of shelled corn per acre whether the seed was planted in hills at the rate of 2 stalks per acre or 3 stalks per acre; or whether it was planted in drilled rows, spaced 14 inches apart or 21 inches apart. There was no apparent difference in size or quality of ears from any of these plots.

Where the corn was drilled and thinned to a stand of one stalk every 7 inches the yield averaged only 29 bushels per acre. The ears were small, with many nubbins. This rate of planting evidently was much too thick for producing a good yield of shelled corn.

Yield of Shelled Corn in Combination with Soybeans

Where one soybean plant was grown with each hill of corn the average yield was 33.4 bushels per acre, or 8.1 bushels less than when corn was planted at the same rate alone. Where two soybean plants were grown in each hill the average yield was 33.1 bushels per acre, or a reduction of 8.4 bushels compared with the plots wherein corn was grown alone. In each case the reduction was approximately 20 percent.

Where the soybeans were drilled with corn at the thickest rate used, or one stalk of corn every 7 inches and a soybean plant alternating with each stalk of corn, the average yield was 23 bushels per acre. This was 6 bushels less per acre than where the corn alone was drilled at this rate. Where the corn was planted as thickly as 7 inches apart there was considerable variation in the yield of shelled corn from year to year whether it was grown alone or in combination with soybeans. In one year the combination yielded more than did corn alone drilled at the same rate.

Table 4.—Yield in Bushels of Shelled Corn per Acre of Corn Grown Alone at Various Rates and in Combination with Soybeans

Crop or Combination	Method and Rate of Planting	Yield in Bushels per Acre for the Years 1921 to 1925					Average Yield 1921-25
		1921	1922	1923	1924	1925	
Corn alone	2 stalks per hill	51.0	40.5	37.1	33.7	40.4	40.5
Corn alone	3 stalks per hill	58.8	42.6	38.9	38.2	39.1	43.5
Corn alone	Drilled 7″	53.1	19.4	21.0	20.4	31.3	29.0
Corn alone	Drilled 14″	54.3	42.9	35.1	30.0	45.2	41.5
Corn alone	Drilled 21″	54.8	45.5	38.8	30.3	38.6	41.6
Corn and soybeans	Drilled 7″	34.9	11.7	26.6	13.6	28.2	23.0
Corn and soybeans	2 stalks corn, 1 plant soybeans	42.2	35.3	33.7	27.9	28.1	33.4
Corn and soybeans	2 stalks corn, 2 plants soybeans	42.2	36.5	30.8	26.3	29.8	33.1

Table 5.—Average Composition of Corn and Soybeans Grown Alone and in Various Combinations, 1923 to 1925 (green weight)

Crop or Combination	Method and Rate of Planting	Constituents (Percent)					
		Dry Matter	Ash	Protein	Fat	Fiber	Carbohydrates
Corn alone	2 stalks	27.07	0.99	2.03	0.65	5.71	23.40
Corn alone	3 stalks	26.36	1.05	1.95	0.63	5.47	22.73
Corn alone	Drilled 7″	25.22	1.22	1.47	0.46	6.06	22.07
Corn alone	Drilled 14″	26.65	1.07	1.82	0.64	5.97	23.12
Corn alone	Drilled 21″	24.36	0.99	1.86	0.52	5.88	20.99
Corn and soybeans	Drilled 7″	26.90	1.22	1.95	0.76	6.85	22.97
Corn and soybeans	2 stalks corn, 1 plant soybeans	26.65	1.14	2.14	0.74	6.30	22.63
Corn and soybeans	2 stalks corn, 2 plants soybeans	26.64	1.24	2.32	0.86	6.46	22.22
Soybeans alone	In rows 30″ apart	27.65	1.90	4.24	1.99	9.08	19.53
Soybeans alone	Solid, 6 pecks per acre	26.68	1.92	3.27	1.41	8.89	20.08

Because of the considerable fluctuation in results from these thickly planted plots, not as much confidence can be placed in the relative difference between the corn-alone and the combination plots as can be placed in the results where a more nearly normal rate of planting was used. When corn was spaced only 7 inches apart, whether grown alone or with soybeans, so much corn was lodged some years and the growth was generally so short that relatively few good ears developed.

Composition of Silage

Since soybeans are high in protein it would be expected that where soybeans are grown with corn, the combination crop would have a higher protein content and hence the feeding value of the silage would be higher than when the corn is grown alone. Some investigators have reported a considerably higher protein content from the combination over corn alone, while others have found only slight increases due to the small percentage of soybeans in the combination.

In order to obtain data on the composition of the silage obtained, chemical analyses were made of the samples taken from the various plots in the years 1923, 1924, and 1925. Where corn and soybeans were grown in combination, separate analyses were made of each crop. The composition of the combination crop was then computed by taking into account the proportion of the total yield made up by each of the two crops. The results obtained are shown in Table 5.

The data in this table show that in the plots where corn was grown alone, the percentage of protein varied from 1.47 percent where the corn was spaced 7 inches apart in the row, to 2.03 percent where the corn was planted at the rate of 2 stalks per hill. The soybeans drilled solid averaged 3.27 percent protein, while those planted in cultivated rows averaged 4.24 percent. In the combination crops the percentage of protein ranged from 1.95 percent in the plots where the corn and soybeans were drilled 7 inches in the row, to 2.32 percent where 2 stalks of corn and 2 soybean plants were grown in each hill.

Protein Content of Silage in the Various Methods Compared

In comparing the average composition of the plots where corn was grown alone at the rate of two stalks per hill, with the plots where corn was planted at the same rate but with one soybean plant in each hill, it was shown that the composition of protein was in-

creased from 2.03 to 2.14 percent by the soybeans. This was an increase only of approximately 0.1 percent. When two soybean plants were grown with the corn the protein content was raised to 2.32 percent, or an increase of approximately 0.3 percent. When only one soybean plant was grown per hill the increase in protein content of the mixture over corn alone was very small, while the increase when 2 plants per hill were grown with the corn was somewhat higher and may be enough to account for a definite increase in the feeding value of the silage.

May 5 seeding of Soybeans on right; May 20, center; later seedings at left

When corn was grown alone and spaced 7 inches in the row the protein content of silage was 1.47 percent, or very much less than where corn was planted more nearly at the usual rates. This result might be expected from the low proportion of grain in the silage. When soybeans were grown with corn planted at this rate, the protein content was increased to 1.95 percent. In this case there was a very material increase in the protein content because of the soybeans in the mixture. The protein content of this combination, however, was only slightly higher than that of the plots where corn alone was drilled either 14 or 21 inches apart in the row. It was slightly less than the average protein percentage of the corn grown alone in 2-stalk hills, and the same as that of the corn in the 3-stalk hills.

The results obtained in these tests therefore show that where one soybean plant per hill was grown with corn at the normal rate of planting corn in hills, practically no increase in protein content over corn grown alone resulted from the combination; where two stalks were grown a small increase resulted; and where the crops were drilled thickly a considerable increase was obtained.

Where the soybeans were grown in cultivated rows there was a very marked increase in average protein content over those plots where they were sown solid. This difference in protein was approximately the same each year.

This higher protein content in the soybeans grown in cultivated rows may be due to several causes. Under cultivation the soil usually has a higher nitrate content than where it is not worked. This cultivation would tend to increase the protein content of the crop grown. The absence of weeds in the soybeans in the cultivated rows and the larger percentage of seed in these plots would also tend to produce a hay with a higher protein content than that from the solid-seeded plots. The soybeans in the solid-seeded plots also were usually a little more mature when cut than those in the cultivated rows. This difference would tend to reduce the protein content of these as compared to the soybeans from the cultivated plots.

In considering the other constituents for which the samples were analyzed, little difference is seen between the various plots in dry matter or carbohydrate content. In ash, fat, and fiber the soybeans are somewhat higher than the corn when grown alone, while the combination usually ranges between these.

Yield of Protein and of Total Nutrients per Acre

Another question in the present discussion is whether the protein yield per acre is increased by growing the combination. Data are available for the years 1923, 1924, and 1925. The results obtained are given in Table 6. Here also is shown the yield of total nutrients per acre for the various plots.

The average yields of protein for the corn grown alone at the rate of 2 stalks per hill, or spaced 7, 14, or 21 inches apart in drilled rows, did not vary significantly from each other. Although the protein content in some of these was higher than in others, differences in yield of green material per acre tended to balance this.

Where 3 stalks of corn were grown per hill there was an average increase of 38 pounds of protein per acre over the 2-stalk plots. One soybean plant per hill increased it by only 9 pounds per acre. Where 2 soybean plants were grown in each hill of corn the increase was 46 pounds per acre. The protein per acre therefore was not appreciably increased by growing one soybean plant per hill; but a significant increase resulted when 2 plants per hill were grown.

Table 6.—Yield per Acre in Pounds of Protein and of Total Nutrients of Corn and Soybeans Grown Alone and in Various Combinations

Crop or Combination	Method and Rate of Planting	Pounds per Acre of Protein and Total Nutrients for the Years 1923 to 1925						Average Pounds 1923-25	
		1923		1924		1925			
		Pro.	T. N.	Pro.	T. N.	Pro.	T. N.	Pro.	T. N.
Corn alone	2 stalks	321	4016	393	3730	286	3913	303	3886
Corn alone	3 stalks	349	4808	319	4209	354	4299	341	4429
Corn alone	Drilled 7″	283	4760	278	4704	336	5180	299	4881
Corn alone	Drilled 14″	344	4834	284	3756	343	5098	324	4563
Corn alone	Drilled 21″	305	3998	264	3355	309	3710	292	3688
Corn and soybeans	Drlled 7″	456	5285	335	4700	456	6342	416	5442
Corn and soybeans	2 stalks corn, 1 plant soybeans	354	4034	284	3479	299	3581	313	3698
Corn and soybeans	2 stalks corn, 2 plants soybeans	368	4017	329	3650	351	3816	349	3828
Soybeans alone	In rows 30″ apart	539	3489	788	4522	633	3851	653	3954
Soybeans alone	Solid. 6 pecks per acre	409	3275	544	4026	565	4188	506	3830

Table 7.—Average Composition of Corn Grown Alone and in Combination and of Soybeans Grown Alone and in Combination, 1923 to 1925 (green weight)

Crop or Combination	Method and Rate of Planting	Constituents (Percent)					
		Dry Matter	Ash	Protein	Fat	Fiber	Carbohydrates
Corn alone (average)	2 stalks; 3 stalks; 14″ drilled; 21″ drilled	26.11	1.02	1.91	0.61	5.76	22.56
Corn in combination (average)	2 corn, 1 soybean; 2 corn, 2 soybeans	26.45	1.09	1.92	0.60	6.15	22.84
Corn alone	7″ drilled	25.22	1.22	1.47	0.46	6.06	22.07
Corn with soybeans	7″ drilled	26.69	1.06	1.54	0.51	6.59	23.28
Soybeans alone	rows	27.65	1.90	4.24	1.99	9.08	19.53
Soybeans with corn (average)	2 corn, 1 soybean; 2 corn, 2 soybeans	28.02	1.92	4.44	2.28	8.19	19.37

The highest yield of protein per acre resulted where corn and soybeans were grown at the rate of corn spaced 7 inches apart in drilled rows with a soybean plant between each 2 stalks of corn. An average increase of 117 pounds of protein per acre was obtained over the plots where corn was grown alone at the same rate.

The soybeans grown in cultivated rows produced 147 pounds more protein per acre than did the soybeans grown in the plots drilled solid.

When the average yield of total nutrients per acre is considered, the data show that this yield was approximately the same for the plots where corn was grown alone at the rate of 2 stalks per hill or 21 inches apart in the row; where one or 2 soybean plants were grown in each hill of corn; and where soybeans were grown alone either in cultivated rows or drilled solid. The plots where 3 stalks of corn per hill were grown or where the stalks were spaced 14 inches apart in the row showed an increase in yield of total nutrients over the 2-stalk plots in about the same proportion as the increase in yield of green material.

The yield of total nutrients per acre was highest in the plot where soybeans were planted with corn and the corn spaced 7 inches apart in the row. Although this combination produced the highest yield of total nutrients as well as the highest yield of protein per acre, this method of planting resulted in much lodged material that was difficult to harvest.

Composition of Corn and Soybeans Alone and in Combination

What effect, if any, does the growing of corn and soybeans in combination have upon the composition of each of these crops? Is the protein content of the corn increased?

Lyon[10] at the New York (Cornell) Experiment Station found that the protein content of several non-legumes when grown in combination with red clover and alfalfa was increased. The Pennsylvania Station[11] did not find any increase in the protein content of corn when grown with soybeans.

The results obtained in the experiments reported in the present bulletin are presented in Table 7.

In getting the average protein content of corn grown alone, the average percent was used of the plots where corn was grown in 2- and 3-stalk hills and also where it was spaced 14 and 21 inches apart in

[10]N. Y. (Cornell) Agr. Exp. Sta. Bul. 447.
[11]Penna. Agr. Exp. Sta. Bul. 167.

drilled rows. The corn grown alone in drilled rows and spaced 7 inches apart was not included in this average since it was much lower than the others. For the protein content of the corn grown in combination, those plots are averaged where one and two soybean plants per hill were grown with the corn.

The average protein content of the corn grown alone was 1.91 percent and of the corn grown in combination with soybeans was 1.92 percent. Obviously the growing of soybeans with the corn in this case had no influence on the protein content of the corn. Corn grown alone and spaced 7 inches apart in the row averaged 1.47 percent, and when soybeans were grown with the corn the protein content of the corn was 1.54 percent. Again no appreciable increase in the protein content of the corn was noted as a result of growing soybeans with it.

In order to determine what effect the growing of the combination had upon the composition of soybeans, the composition of the legume grown alone in drill rows was compared with the average of the soybeans grown with corn at the rates of one and of two plants per hill. This is probably the best comparison that can be made among the various combinations in this test. The protein content of the soybeans grown alone was 4.24 percent and where grown in combination with corn, 4.44 percent. This difference is small and probably of no significance. It would seem from these results that the growing of the combined crops did not have any influence on the protein content of either the corn or the soybeans.

DISCUSSION

The growing of corn and soybeans together for silage would hardly seem a justifiable practice from the results obtained in these experiments. Growing the combination did not increase the total yield per acre of silage while the protein content of the combined crop was only a little higher than where corn was grown alone. This result was due largely to the small proportion of soybeans in the combination. The yield of protein per acre was increased only to a small extent, while the yield of total nutrients per acre was not increased. The proportion of soybeans in the corn varied considerably from year to year even under these controlled conditions. In actual practice it would therefore be difficult to estimate to what extent the composition of the silage would be affected by growing the two crops together.

The growing of the combination involves extra work in planting, culture, and harvesting. The increases obtained do not justify this additional work.

Under the conditions of this experiment, where soybeans grown alone produced practically the same tonnage per acre as the corn grown alone it would seem a much more desirable practice to grow the two crops separately and then mix them in the desired proportion when filling the silo. In this way the composition of the silage can be much more satisfactorily controlled.

The results obtained indicate that for silage the corn grown alone should be planted at the rate of about 3 stalks per hill or spaced about 14 inches apart in drilled rows. The planting of the corn at the rate of 2 stalks per hill or spaced 21 inches apart in the row did not produce as good yields as the heavier planting. Where the corn was grown at the rate of 1 stalk every 7 inches in the drilled row, more tonnage was obtained per acre, but the feeding value was considerably less per unit of weight because of the low proportion of grain produced.

Where weeds are troublesome it will probably be advisable to grow the soybeans in cultivated rows for silage. Although a coarser growth results than where the crop is drilled solid, this is not an important factor if the beans are to be used for silage.

SOYBEANS FOR HAY

Soybeans are more extensively used in West Virginia for hay than for any other purpose. As a hay crop soybeans compare very favorably with both red clover and alfalfa. Feeding trials conducted by the department of dairy husbandry at this Station[12] gave results indicating that, properly handled, soybean hay is equal in feeding value to a good grade of alfalfa hay. The yields of soybeans also compare very favorably with other forage crops commonly grown. Soybeans are also the most dependable legume grown in the state. Good yields are often obtained on land where it is difficult, if not impossible, to get a good stand of either red clover or alfalfa.

Several questions often arise with respect to the best methods of growing soybeans when they are to be used for hay. Among these are: What is the proper rate of planting the crop? When is the proper time to plant, and are there some crops which may be grown to advantage in combination with the soybeans for hay? In an endeavor

[12]W. Va. Agr. Exp. Sta. Bul. 181.

to answer these questions the following experiments were started. In an earlier test conducted at this Station,[13] results were obtained over periods of one and two years which gave some indications of what might be expected.

METHODS USED IN EXPERIMENTS

In the experiments where the soybeans were planted at various rates of seeding per acre and also where different dates of planting were used, the plots were planted in solidly drilled plots one drill-width wide and eight rods in length, making a plot approximately 1/40 acre in size. The two outside drill rows of each plot were cut and discarded before harvest each year to eliminate border effect as far as possible.

In the date-of-planting experiment the plots were planted at a uniform rate of 8 pecks per acre.

Where soybeans were grown in combination with various other crops the soybeans were planted in drill rows spaced 28 inches apart. At the first cultivation or when the soybeans were about 3 inches in height, the other crops were planted between the rows of soybeans. The millet was sown broadcast while the sorghum and Sudan grass were seeded with a garden seeder. Only the two center rows of each plot and the corresponding interplanted crops were used for yield determination.

Four plots of each rate and date of planting, as well as of different combinations of crops, were grown each year. The yields were determined by weighing the hay in the field when it was considered properly cured. A sample was taken at this time in order to determine the moisture content. In drying, this sample was handled in the same manner as has been described for the silage samples. All yields were reported on an air-dry basis. Had these yields been reported as field-cured hay they would have averaged about 15 percent higher.

Wilson soybeans were used in all experiments.

Rate of Planting

The yields obtained in the rate-of-planting experiment are given in Table 8.

The data in Table 8 show that there was little difference in yield between the various rates of planting. The yields ranged from 2.12

[13] W. Va. Agr. Exp. Sta. Bul. 172.

tons of air-dry hay per acre for the 5-peck seeding to 2.23 tons for the 8-peck seeding. The increase of the 8-peck seeding was only about one-tenth ton of air-dry hay per acre over the 4- and 5-peck seedings. The 6-peck seeding was intermediate between the 8-peck and the thinner seedings.

Although little difference was noted in the yields obtained from

Table 8.—Yield in Tons per Acre of Air-dry Hay from Soybeans Planted at Various Rates

Rate of Planting in Pecks per Acre	Yield in Tons per Acre of Air-dry Hay for the Years 1921 to 1925					Average Yield per Acre 1921-25
	1921	1922	1923	1924	1925	
4 pecks	2.49	1.99	2.15	1.65	2.40	2.14
5 pecks	2.36	2.18	2.08	1.57	2.40	2.12
6 pecks	2.50	2.25	2.15	1.63	2.36	2.18
8 pecks	2.53	2.36	2.14	1.69	2.45	2.23

the plots planted at various rates, there was a very striking difference between them in the quality of the hay produced and in the amount of weeds in the hay. Where only 4 or 5 pecks were seeded the hay produced was considerably coarser than when 8 pecks per acre were seeded. With the 6-peck seeding the hay was intermediate in this respect. The most marked difference, however, was found in the amount of weeds in the hay. Where only 4 or 5 pecks were seeded the hay generally consisted of a considerable proportion of weeds. Although there were some weeds in the hay when 8 pecks per acre were seeded, the proportion was very much less. In this respect also the 6-peck seeding was intermediate between the thinner rates of seeding and the 8-peck seeding.

The best rate of planting for soybeans will depend somewhat on the variety and the condition of the land. With large-seeded varieties like Mammoth Yellow it is necessary to plant at a heavier rate than with a small-seeded variety like the Peking. On land that is inclined to be weedy the soybeans should be planted more thickly than where the land is comparatively free from weeds.

With the Wilson soybean, a medium-size bean, it would seem advisable to plant from 6 to 8 pecks per acre. Where the land is inclined to be weedy the heavier planting should be used.

Time of Planting

The results obtained when the soybeans were planted at different dates are given in Table 9.

The yields in air-dry hay ranged from 1.93 tons per acre for the

Table 9.—Yield in Tons per Acre of Air-dry Hay from Soybeans Planted on Various Dates

Date of Planting	Average Date Harvested	Yield in Tons per Acre of Air-dry Hay for the Years 1925 to 1927			Average Yield per Acre 1925-27
		1925	1926	1927	
May 5	Aug. 25	1.88	2.36	2.82	2.35
May 20	Sept. 2	1.72	2.79	2.37	2.29
June 1	Sept. 8	1.79	2.66	1.92	2.12
June 10	Sept. 12	1.93	2.16	2.21	2.10
June 25	Sept. 20	1.79	2.27	1.77	1.95
July 10	Oct. 2	1.32	2.43	2.03	1.93

Table 10.—Yield in Tons per Acre of Air-dry Hay from Soybeans Grown Alone and in Various Combinations

Crop or Combination	Yield in Tons per Acre of Air-dry Hay for the Years 1921 to 1925					Average Yield per Acre 1921-25
	1921	1922	1923	1924	1925	
Soybeans alone	3.15	2.60	1.84	1.45	1.88	2.18
Soybeans and millet	3.03	2.28	1.95	2.50	1.79	2.11
Soybeans and Sudan grass	3.12	2.11	1.93	1.28	2.23	2.13
Soybeans and sorghum	2.89	2.01	1.89	1.35	2.32	2.07

July 10 seeding to 2.35 tons when seeded May 5. The yields fluctuated somewhat from year to year, depending on the season. Although the difference in actual yield is not great between the different dates, there were marked differences in the quality of the hay produced. When the soybeans were planted as early as May 5 there was a much higher percentage of weeds in the hay each year than when they were planted at a later date. The soybean does not make a vigorous growth until the soil is thoroughly warmed. Planting earlier gives many weeds an opportunity to become established before the soybeans can furnish sufficient competition.

Planted as late as July 10 the beans were so late in maturing sufficiently to cut for hay that considerable difficulty was encountered in curing them. The same was true to a lesser extent when they were planted June 25.

From these experiments it would seem that for best results under West Virginia conditions, soybeans should be planted sometime between the middle of May and the middle of June. In earlier plantings weeds are likely to cause difficulty, while planting later than the middle of June makes the beans so late in maturing that the curing of the hay gives considerable trouble.

Soybeans in Combination for Hay

Soybeans are more difficult to cure than the ordinary hay crops. For that reason it is sometimes desired to grow some other crops with

them in order to facilitate curing. If a satisfactory crop can be found to grow with the soybeans the combined crop would also be easier to cut and handle, since the companion crop would tend to keep the soybeans from lodging. Among crops that are often suggested as suitable for growing with soybeans for hay are Sudan grass, sorghum, and millet. In order to test out the value of these crops when grown in combination with soybeans for hay, each one was grown with soybeans, and the yields determined. The results obtained are shown in Table 10.

As the data in this table show, there was little difference in yield between soybeans grown alone and any of the various combinations. The yields ranged from 2.07 tons of air-dry hay per acre for the combination of soybeans and sorghum to 2.18 tons when soybeans were grown alone.

Of these combinations the Sudan grass and soybeans made the most desirable mixture. Millet was not satisfactory, largely because it reached maturity much earlier than the soybeans. Even when planted after the soybeans were 3 or 4 inches high it was ready to cut 10 days before the soybeans had matured sufficiently for hay. Sorghum, although maturing more nearly with the soybeans, was too coarse for hay. This combination also cured very slowly. On account of its coarseness and the difficulty in curing, this combination cannot be recommended.

While the Sudan grass and soybean combination did not produce a heavier yield than soybeans grown alone, the combination proved to be more easily cured and was handled more easily than soybeans grown alone. This combination has done remarkably well in some trials in other parts of the state, especially where the soil is rich. On thin soils there is probably not much to be gained by growing the combination over soybeans alone. On bottom soils of high fertility the combination makes an excellent crop for hay.

Soybeans with Millet (right), Sudan grass (center), and Sorghum (left)