METHODS OF CURING SOY BEAN HAY

THESIS FOR THE DEGREE OF M. S.

Henry Lankford Dunton

1932

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TABLE OF CONTENTS

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A Thesis Prepared by

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Department of Farm Crops

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INTRODUCTION

Improper cultural practices and adverse weather conditions often result in the failure of alfalfa and clover seedings. This condition necessitates the need for an annual hay crop to supply high protein forage during the winter months.

The soy bean is an annual legume and when properly cured is comparable to alfalfa in feeding value. Yields of from 1.5 to 2.5 tons of hay per acre may be expected where the local varieties of dent corn mature for grain. Soy bean hay is eaten readily by livestock. These qualities aid in making the soy bean one of the leading high protein emergency hay crops for the southern section of the lower Peninsula.

The large stems and leaves and the slow moisture loss make the soy bean more difficult to cure under similar conditions than alfalfa. The soy bean is ready to harvest for hay in September when rainfall is frequent and general weather conditions unfavorable for the curing of hay. Approximately six days of favorable weather are required to cure soy bean hay and weather reports show that during the past ten years there have not been six consecutive days without rain during this period. The fact of natural difficulty in curing and adverse weather conditions make the soy bean one of the most difficult hay crops to cure in this section.

Several methods of harvesting and curing soy beans for hay were compared to determine the best method of handling the crop so that it will not be damaged by rain and mold.

REVIEW OF LITERATURE

A review of literature indicates that a comparatively small amount of work has been done to determine the most efficient method to cure quality soy bean hay. Methods used and results obtained in curing alfalfa hay will be cited principally since this crop is a legume and bears a direct relation to soy beans.

The production of quality hay requires that certain processes take place when the hay is curing and that the hay possess certain qualifications when cured. Kiesselbach (6) of Nebraska gives the following attributes of quality hay:

The hay is pure.

It shall retain a high per cent of leaves.

Clinging foliage.

Pliable stems.

Green color.

Free from moisture and moldiness.

Stewart (20) gives the processes that must take place while the hay is curing:

Reduction of moisture as quickly and uniformly as possible.

Development and preservation of aroma.

Avoidance of waste due to loss of leaves and injured hay.

The uniform loss of moisture from stems and leaves as quickly as possible is one of the most difficult and important curing processes. There is a tendency for the leaves of the soy bean to dry rapidly and become brittle before the stems are sufficiently dry to stack or store. Delaying the drying of

the leaves and hastening the drying of the stems is essential to produce the highest quality hay. The retention of a high per cent of leaves is essential as they make up forty to forty-five per cent of the hay and contain approximately fifty per-cent protein. The correct amount of fermentation is essential to develop the proper aroma so that the hay will be relished. The processes that take place in the curing are essentially linked, each being necessary for the other to develop properly.

Megee (12) states that to secure the largest yield of hay and highest food value the soy beans should be cut when the beans are one-half developed and before the bottom leaves turn yellow and drop.

Willard (23) gives the following results:
The weight of leaves increase until beans are well formed, remains constant for three weeks and then decreases. The weight of stems reach a maximum when the beans are well formed and remains constant thereafter, the per cent of stems increases as leaves drop.

Whether the hay will be used on the farm or sold, influences to some extent the curing. The soy bean is an emergency hay crop in Michigan and the hay is usually fed on the farm.

Curing Methods Practiced in the U. S.

Morse (15) gives the general methods that are used to cure soy beans in the U. S.:-
Method I. - The soy beans are cut as soon as the dew is off and left in the swath until the leaves are well wilted which requires one day of favorable weather. The second day or

when the hay is well wilted, it is placed in the cock for the remainder of the curing process which requires three to five days.

Method 2. - The entire curing process takes place in the swath which requires little labor but a lower quality hay is produced due to exposure. The hay is raked when slightly damp and either stacked or stored.

Method 3. - The hay remains in the swath until the leaves are wilted and is then windrowed by the use of the side delivery rake. The hay remains in the windrow until cured being turned whenever conditions permit.

Method 4. - The soy beans are left in the swath until wilted and then placed on a frame of some kind to complete the curing process. This method is followed in the southern states using the rick, tripod, ventilated stack and curing truck.

Stewart (20) found the following to be true when alfalfa was exposed to three rains in fifteen days totaling 1.75 inches.

Alfalfa Hay

Per cent	Ash	Protein	Fiber	Carbohydrates	Fats
Original hay	12.2	18.7	26.5	38.7	3.9
Damaged hay	12.7	11.0	38.8	33.6	3.8

The per cent of ash and fiber increased due to the decrease in proteins, carbohydrates and fats. Sixty per cent of the crude protein, thirty three per cent of the fat, forty one per cent of the nitrogen free extract or thirty

two per cent of the total dry matter was lost when exposed to rain.

Kiesselbach (5) conducted a number of tests in Nebraska to answer numerous questions concerning the curing of alfalfa hay. A direct relationship existed between the per cent of leaves present and the protein content of the hay. The time of day the hay was cut did not influence the rate of curing or the final product. The larger the windrow the slower the loss of moisture. Cocked hay required three times as long to cure as did the average size windrow and was lower in quality.

EXPERIMENTAL

General Outline

Different methods of curing soy bean hay were conducted at the college farm to determine the most practicle and efficient system to use under Michigan conditions. The experiment was started September II, 1931 and continued for twenty-one days or until the hay was cured.

The tests of the curing methods were conducted on two fields. Each field was divided into eight quarter acre plots fourteen yards wide and eighty seven yards long.

A section of each field was sown broadcast and the remainder drilled in twenty eight inch rows. The soy beans drilled in rows and cultivated were practically free from grass and weeds while those sown broadcast contained a large amount of foxtail and the growth of the soy beans was lighter. A portion of the soy beans were a little past the proper stage to cut for hay, some of the bottom leaves having turned yellow and dropped. This condition existed particularly on the knolls and was influenced by soil type and moisture.

The plots ran across both drilled and broadcast seedings, giving a representative sample of the soy beans in each plot. The diagrams on pages 3 and 4 give a layout of the plots and the curing methods that were outlined and methods followed. The outlined procedure was changed in several cases, the principle changes being in the length of time the hay remained in the swath and the windrow. It was

necessary to make the changes due to the damp weather. Where the hay was handled immediately after cutting as in the binder method there was no change of procedure.

FIELD B — Figure I

BEANS CUT AFTERNOON 9-12-31

Plot I	Plot II	Plot III	Plot IV	Plot V	Plot VI	Plot VII	Plot VIII
			Procedure Outlined				
Swath Curing	Swath 3 days Windrow 4th day ½ turned	Swath 3 days Windrow 4th day ½ turned	McNaughton	Swath 1 day Cock 2nd day	Windrow Immediately after cutting ½ turned	Cocked immediately after cutting	Rick or tripod
			Procedure Followed				
Method Followed	Swath 5 days Windrow 6th day ½ turned	Swath 5 days Windrow 6th day ½ turned	Swath 5 days Stack 6th day	Swath 5 days Cock 6th day	Method Followed	Method Followed	Swath 4 days Windrow 1 day Stacked 6th day

FIELD A — Figure 2

SOY BEANS CUT AFTERNOON 9-11-31

Plot I	Plot II	Plot III	Plot IV	Plot V	Plot VI	Plot VII	Plot VIII
Procedure Outlined							
Swath Curing	Swath 3 days Windrow 4th day ½ turned	Swath 2 days Windrow 3rd Day Cock 4th day	McNaughton	Windrow immediately After Cutting	Windrow immediately After Cutting Turned	Cock immediately After Cutting	Binder Stacked as soon as Cut
Procedure Followed							
Method Followed	Swath 5 days Windrow 6th day ½ turned	Swath 5 days Windrow 6th day Cock 7th day	Swath 5 days Stack 6th day	Method Followed	Method Followed	Method Followed	Method Followed

Table I and figures 3, 4 and 5 show that the September precipitation is higher than any month in the year except May which exceeds it by .15 inch. The average rainfall per month from 1922 to 1932 is 2.34 inches while the September rainfall is 3.15 inches which is .81 inch above monthly average. The September precipitation in 1931 was 3.33 inches which is .18 inch above September average for ten years and .98 inch above monthly average.

The weather, from September II when the experiment was started to October 1st, was unfavorable for hay curing. Immediately after cutting the hay there was six days with sufficient precipitation to prevent handling the hay. The weather during the remainder of the curing period was principally damp and delayed the curing process. Only twice was there sufficient wind and sunshine so that the hay was sufficiently dry to handle to the best advantage.

Six consecutive days of favorable curing weather are required to cure soy beans so that they may be stored without danger of loss. Weather reports show that during the past ten years there have not been six consecutive days without rain during this period. A method that will allow the hay to be handled so that it will not be damaged by damp weather would prove the best at this season of the year.

Table I

Weather conditions for September 1931

Date	Mean temperature	Inches precipitation	Character of day
1	66 degrees C	.23	Cloudy
2	64	Trace	Cloudy
3	63	.00	Clear
4	66	.25	Partly cloudy
5	68	.00	Partly cloudy
6	65	.00	Clear
7	64	.00	Clear
8	72	.05	Partly cloudy
9	78	.37	Partly cloudy
10	78	Trace	Partly cloudy
11	80	.00	Clear
12	79	.13	Partly cloudy
13	78	.40	Partly cloudy
14	73	.54	Cloudy
15	65	.06	Cloudy
16	70	.07	Cloudy
17	68	.30	Partly cloudy
18	57	.00	Cloudy
19	64	.06	Cloudy
20	76	.00	Clear
21	80	.00	Clear
22	70	Trace	Partly cloudy
23	70	.02	Partly cloudy
24	56	.00	Clear
25	55	.81	Cloudy
26	54	.04	Cloudy
27	52	.00	Partly cloudy
28	51	.00	Partly cloudy
29	56	.00	Clear
30	58	.00	Clear

Mean temperature for month	66.5
Mean temperature normal monthly	61.4
Total precipitation this month	3.33 inches
Normal precipitation this month	2.91 "
Excess precipitation this month	.42 "
Clear days	9
Cloudy days	9
Partly cloudy	12

Summary of weather from Sept. II, to October Ist

Mean temperature	65.6
Total precipitation	2.43 inches
Average daily	.122 "
Clear days	6
Cloudy days	7
Partly cloudy days	7

Figure 3

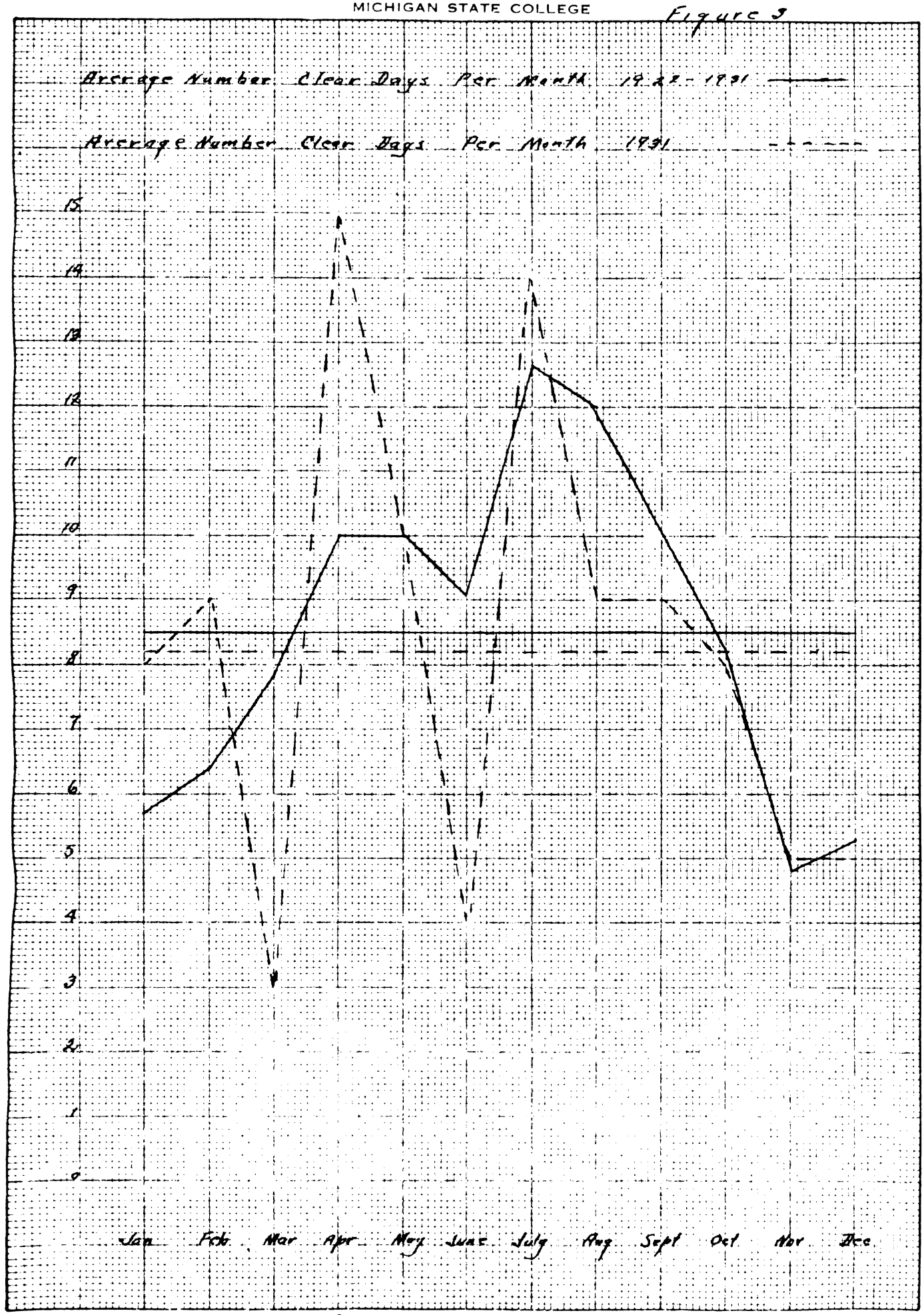

Average Number Clear Days Per Month 1922 - 1931
Average Number Clear Days Per Month 1931
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

Figure 4

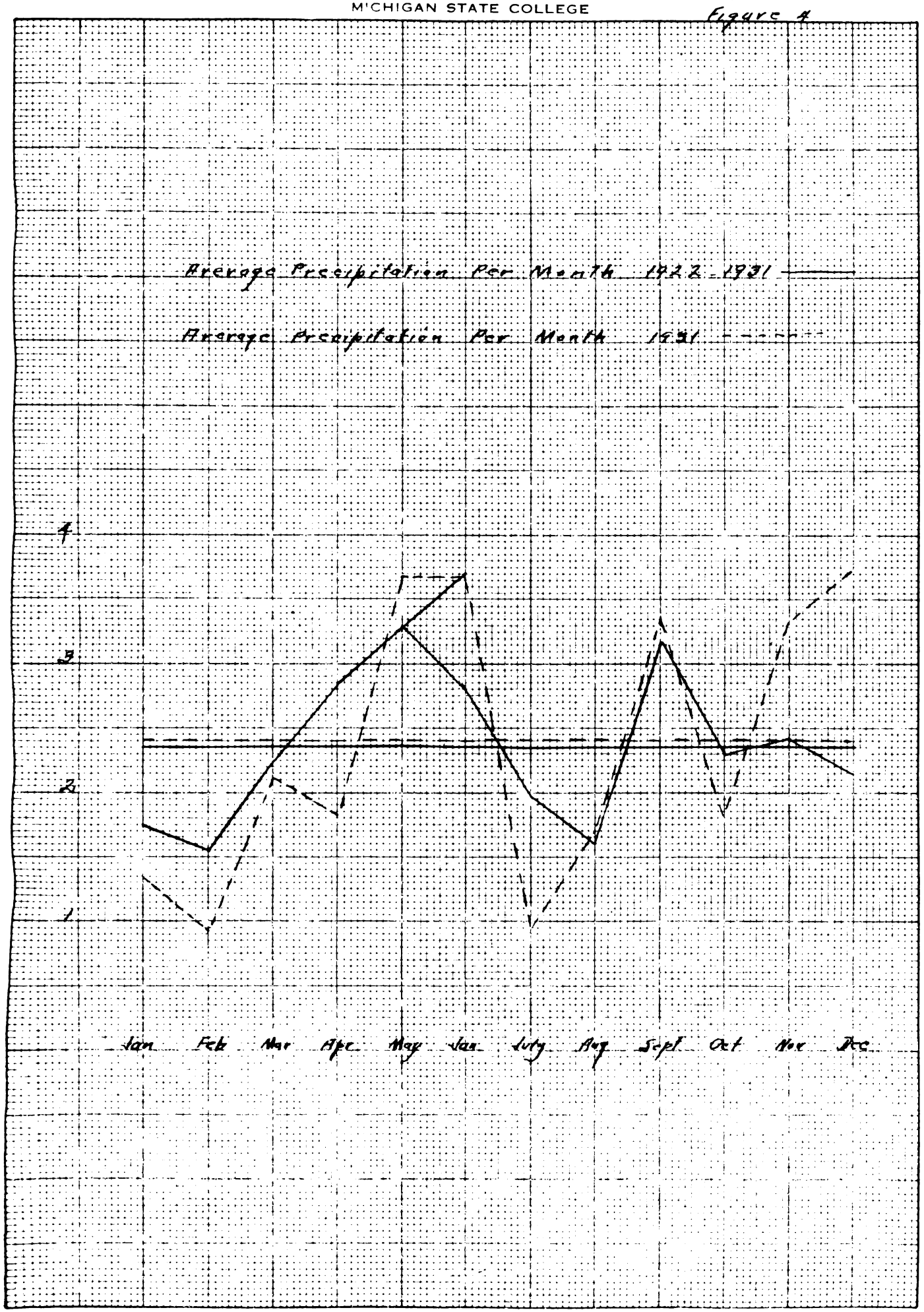
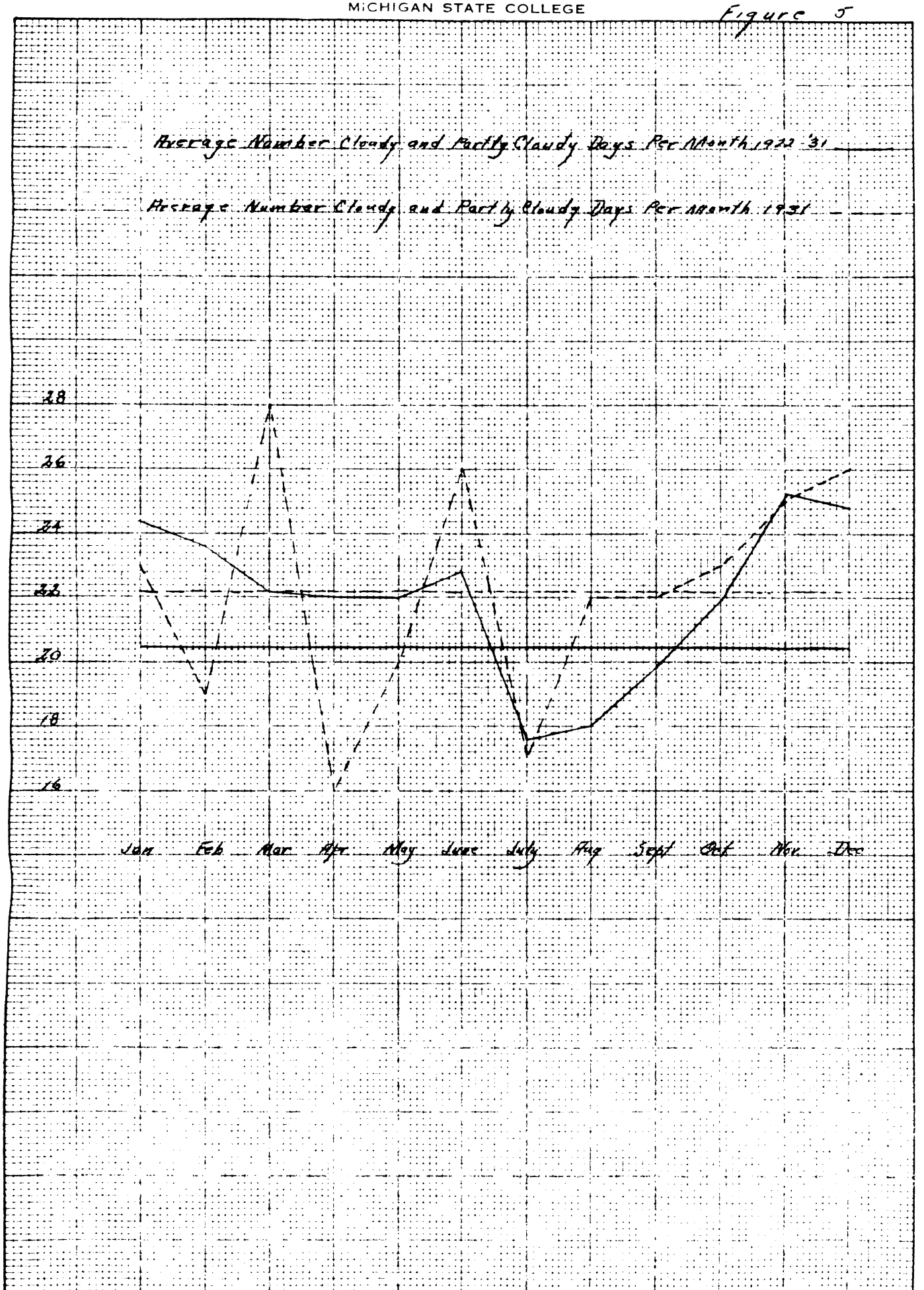

Average Precipitation Per Month 1922-1931
Average Precipitation Per Month 1931
4
3
2
1
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sept
Oct
Nov
Dec

Figure 5


Average Number Cloudy and Partly Cloudy Days Per Month 1922-31
Average Number Cloudy and Partly Cloudy Days Per Month 1931
28
26
24
22
20
18
16
Jan
Feb
Mar
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec

PROCEDURE

The soy beans in Field A were cut September II, 1931, from two until five o'clock in the afternoon. The afternoon was clear with a gentle breeze from the south west, apparently an ideal day to start the curing. The cutting was done with a mowing machine except Plot 8 which was cut with a grain binder.

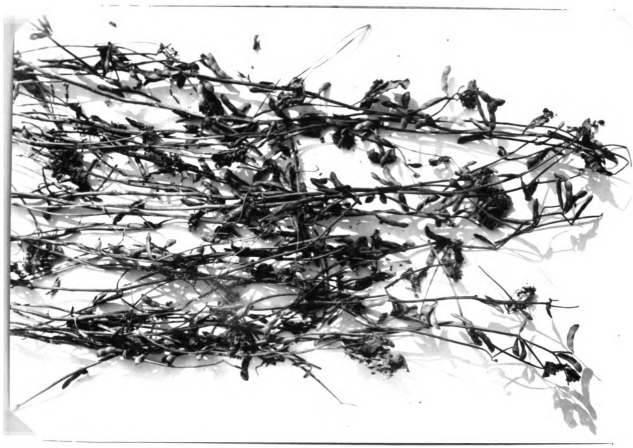
Samples of the hay were taken immediately after cutting to determine the original moisture content. Samples of leaves, stems and beans and a composite sample were taken of immature, mature, and very mature soy beans. The samples were weighed immediately to prevent error due to loss of moisture. The average weight was six pounds. The drying was done by hanging the samples in the barn where there was a free circulation of air on all sides.

The cutting was done across the drilled and broadcast seedings so as to secure a representative sample of mature and immature and clean and grassy soy beans in each plot. Each plot contained four swaths and the windrows contained two swaths.

Results of each plot

Plot I:

The curing was done entirely in the swath and the hay was not disturbed after cut. Representative samples of the hay were taken at regular intervals to determine the rate of moisture loss and when the hay could be safely stored or stacked.



Representative sample of soy beans taken from the swath cured plot in Field A. There are few leaves present and those remaining dark colored and low in quality.

The day after cutting the hay the weather was cloudy and damp except for a limited amount of sunshine in the afternoon. The hay became damp and the under side of the swath was wet. The frequent rains and the large amount of damp weather prevented the proper curing of the hay. The hay on the under side of the swath remained damp from the begining of the curing period. The limited amount of sunshine was insufficient to dry the hay so that it could be safely stored.

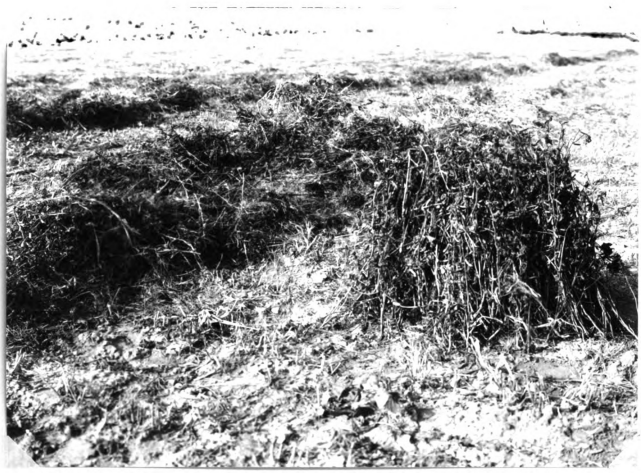
Two days after cutting, the leaves on the under side of the swath showed the development of mold becoming dark in color and eventually rotting. The fifth day mold and rot was found on the stems and beans. This condition arose before the hay was sufficiently dry to store. When the weather conditions were such that the hay was allowed to dry so that it could be safely stored its value as a feed was worthless. The small per cent of leaves that remained were bleached and poor in quality.

The use of a tedder is not practical, resulting in the loss of a large per cent of leaves which is the most valuable part of the hay. The hay that contained the grass was slightly superior to the clean hay as the leaves contained less grit. The light growth of soy beans aided the curing process. A heavy growth would have resulted in poorer quality hay. The results show that swath curing alone under the conditions that existed could not be recommended.

Plot 2:

The hay remained in the swath six days or double the time outlined, under favorable curing conditions this would have been longer than necessary. The hay when windrowed on the sixth day was damp on the top and wet on the lower side of the swath being inferior in quality after exposure to the damp weather. Windrowing the hay at this time even though very damp enabled it to dry quicker by having a freer circulation of air. Raking the hay while the leaves were damp reduced the loss to a minimum. Approximately fifty per cent of the leaves were lost when the hay was windrowed, the principle loss occuring on the under side of the swath where the leaves had stuck together during the damp weather. One-half the windrow was turned whenever conditions permitted, though producing a poor quality hay it was superior to the unturned windrow at the end of the curing period. The hay on the lower side of the unturned windrow was moldy and rotten, being worthless for feed.

The grass had a decided influence on the quality of the hay the same as in plot I. A higher quality hay was produced containing less grit and a smaller per cent of the leaves were lost where the grass was present. A large per cent of grass would not be desirable as it would injure the growth of the hay. The amount present proved beneficial in the curing of the hay in this experiment. The grass cures quicker than the soy beans and allows a freer circulation of air through the hay.



Soy bean hay in Field A curing in the swath and windrow. The plants at the right, standing were taken from the windrow and show dark color and loss of leaves. A large amount of grass is present in the hay in the background.

The hay in the unturned windrow was useless as feed. The turned windrow was of superior quality but lost a larger per cent of the leaves in the turning. The turned or unturned windrow hay could not be classed as feed but both were superior to the swath cured hay.

Plot 3:

As outlined the hay should have remained in the swath two days in the windrow one day and cocked the fourth day. The hay actually remained in the swath five days, windrowed the sixth day and was cocked the seventh day. The damp weather necessitated this change. Windrowing and cocking the hay caused the loss of a large per cent of leaves.

The hay containing the grass was sufficiently dry to cock while the hay containing no grass was a little damp but due to cloudy weather and the forecast for rain all the hay was cocked at the same time. The cocks were constructed very similar to those on farms in the state. The drier hay or that containing the grass was placed in larger cocks than the clean or damper hay. The size of the cocks may be judged from the pictures. The loss of leaves resulted in a poor water shed and the inside of some of the cocks soon became damp. Dampness was present principally in the cocks that contained no grass while those containing the grass did not leak and cured in better condition. The grass aided in the water shed and ventilation of the cock. The section of the cock on the ground and the top few inches was lost due to being wet. The cocks that did not leak dried and could be used as roughage

but could not be classed as quality hay. This hay was not exposed to the damp weather while in the swath and windrow for as long a period as Plots I and 2 which accounts in part for the fact that it was slightly superior in quality.

Plot 4:

The McNaughton system of curing beans as used in Michigan was used to cure the hay. A steel fence post is used or any post seven or eight feet long that can be easily driven in the ground to a depth of twelve to eighteen inches so that it will be sturdy and strong. Sufficient straw is placed around the post so that it will be four to six inches thick when settled. The straw is approximately four feet in diameter for bean stacks, however four to six feet prove better for soy beans eliminating all chances of the hay extending over the edge of the straw and becoming damp. Care must be exercised when beginning the stack to prevent the extension of the hay over the edge of the straw. Four to six inches of straw should extend out beyond the hay leaving three to three and one-half feet for the diameter of the stack. The stack is constructed in the form of a cylinder and the sides are nearly perpendicular. One of the primary requisites of a well made stack is proper capping. The hay should extend eighteen to twenty inches above the top of the pole so that after settling the hay still remains well above the top of the pole and does not give an opportunity for leakage which may result if the pole extends out beyond the hay.

The soy beans remained in the swath five days and were windrowed the sixth day. The hay containing the grass

was stacked on the seventh day and the clean hay was stacked on the ninth day. The hay containing the grass dried quicker and in better condition and therefore could be stacked earlier than the clean hay. The hay stacked on the ninth day was damp on the upper side and wet on the lower side of the windrow being in very poor condition to stack. The stacking was done as an experiment to determine how damp soy beans may be stacked by this method and still dry without molding. A cock was made under identical conditions as a comparison.

The stacks of hay remained in the field thirty days during which time the rainfall was above the average. At the end of this period the stacks were torn down and carefully examined and in every case were dry and in good condition. No difference could be detected between those stacks containing the dry or wet hay when stacked. There was no loss of hay around the bottom as is found in all cocks. The hay that was cocked while damp had molded in the center and the cock throughout was in very poor condition.

The favorable results secured from stacking the damp hay indicate that the soy beans may be placed in the stack directly from the swath when wilted and cure quality hay under adverse conditions. This allows the hay to be placed in the McNaughton stacks soon after cutting which greatly reduces the chances of loss due to wet weather.

Several of the stacks were improperly constructed, being more cone shaped than cylindrical and the hay settled below the top of the pole. Some leakage occured but the amount was insignificant. Considering the condition of the

hay when placed in the stacks and the quality at the end of the 30 day curing period the results were favorable.

Plot 5:

The hay was raked one hour after cutting into a two swath windrow by the use of the side delivery rake. The remainder of the curing process was in the windrow. The growth of soy beans was lighter than in plots 1, 2, 3 or 4. The presence of grass aided in the curing process, the grass curing much quicker than the soy beans gave a freer circulation of air through the hay and kept the leaves freer of grit. A heavy growth of soy beans with no grass present cured poorly. There was a large amount of mold and decay present and the leaves were gritty.

The clean and grassy hay were both useless as feed at the end of the curing period. The results indicate that it is not advisable to windrow a heavy growth of soy beans as soon as cut especially where there is no grass present. Curing soy beans in the windrow alone at this season of the year is not advisable due to the excessive amount of cloudy damp weather.

Plot 7:

The hay was cocked two hours after cutting into small cocks containing approximately three to four forks of green hay and one to two forks when well cured. Two types of cocks were constructed, in the first the hay was rolled with no attention to the capping or the formation of a well made cock, in the second each fork of hay was placed in the cock and the cock well capped so as to prevent leakage. This gave a direct

comparison between proper and improper cocking.

The hay that was rolled into the cock was lost in every case, becoming wet and remaining so throughout the entire curing period causing mold and rot to develop which rendered the hay valueless. The properly constructed cocks showed varied results at the end and during the curing period. The soy beans that were well matured and contained grass cured fair, being free from mold and decay in the center of the cock. The usual loss of hay occured on the ground and the top few inches. This hay could be used as a roughage but could not be classed as quality hay. The soy beans that were green, clean and of heavy growth developed mold and decay in the center of the cock due to early cocking and not to leakage. The soy beans that were green but contained some grass gave varied results, some cocks cured in good condition while others leaked and molded. The cause of this difference is not known.

The majority of the properly constructed cocks were in fair condition at the end of the curing period. The hay could be used as a roughage but could not be classed as quality hay. The usual loss of hay on the lower side of the cock and the top few inches is a factor to consider since there are a large number of cocks per acre. Cocking a heavy growth of green soy beans that contain no grass immediately after cutting usually results in mold and loss of the hay. Partial curing in the swath and windrow would give a better quality hay.

Plot 8:

A binder was used to harvest the soy beans. The binder was set to tie smaller bundles than the regular size, resulting in a constant flow of bundles from the binder. The section of the plot that contained the grass was difficult to harvest. The hay was not cut clean and there was a tendency of the binder to clog and stop. No difficulty was experienced where the soy beans were clean and planted in rows. The lay out of the plots across the drilled rows necessitated the cutting of the hay across the rows which caused a jerking or unsteadiness of the binder and as good results could not be expected as if the binder had been run with the rows. A binder run with the row should have no difficulty cutting clean soy beans.

The hay was shocked as soon as cut into long narrow shocks two bundles wide and three to six bundles long running north and south. The tops of the bundles were pressed together as they were shocked to aid the water shed.

Soy bean hay cut with the binder and stacked in six bundle stacks immediately after cutting. There is no loss of leaves, the hay bright in color and very good grade.

The presence of grass caused a poor water shed and in every case the bundles were wet and moldy on the inside. The grass in some manner held the bundle open and allowed leakage which could not be prevented. The clean soy beans were in excellent condition at the end of the curing period. The bundles had remained dry in the center and the leaves were bright showing that the water shed had been perfect or nearly so.

The hay produced by this method was superior to that produced by any of the other methods. There was little loss of leaves and the leaves were free of grit and bright in color. The binder method, while curing the hay at a slower rate, allows the hay to be handled immediately after cutting so that it is not damaged by damp weather which is a very important factor at this season of the year. The results indicate that the binder method of curing soy bean hay has very good possibilities where the hay is free of grass and a binder in good condition.

Field B

The soy beans in this field contained less grass and were a little more mature than in field A. A heavy growth of pusley on the south side of the field or in plot 8 had caused the growth of the soy beans to be lighter. The soy beans on the north side of the field or those in plots 1 and 2 were more mature and of heavier growth.

The soy beans were sown both broadcast and drilled in twenty eight inch rows the same as field A. The drilled rows ran north and south while the plots ran east and west so that a representative sample of the hay would be in each plot.

The broadcast soy beans contained a very limited amount of grass which did not influence the curing process. The stage of maturity was more advanced than in field A, more yellow leaves, the pods further developed and the moisture per cent was lower. This condition existed particularly in the north section of the field. The hay being more mature naturally cured more rapid than in field A.

The methods of curing and the general procedure followed are essentially the same as field A, field B being used as a check. The layout of the plots was given on page 4 showing the method of curing outlined and followed. The hay was cut on the afternoon of September 12, 1931. The weather was cloudy and damp but not raining. Samples of stems, leaves, beans and a composite sample of immature, mature and very mature plants were taken as soon as cut to determine the original moisture content. Sampling was done in the shade and the samples were weighed immediately to prevent error from loss of moisture. The average weight of the samples was six pounds.

The hay in plot eight was cured by the rick or tripod method instead of the binder as used in plot eight of field A. This was the essential difference in the curing methods of the two fields.

Plot I:

The hay was cut September 12th and was not disturbed. The curing was done entirely in the swath. The soy beans were more mature in the lower section on the east end of the plot. The bottom leaves had turned yellow and began to drop. The

cause of the mature condition in the lower section is not known unless it was due to difference in soil type. The over ripe condition of the soy beans will influence the curing of the hay. The shattering of leaves when handled will be difficult to prevent since a large per cent of the leaves shattered when the hay was cut.

The hay was exposed to a large amount of cloudy, damp weather making the curing difficult. The quality would have been inferior under favorable curing conditions as the percentage of leaf loss would have been high. At the end of the curing period or when the hay was sufficiently dry to stack or store a large per cent of the leaves had shattered even though the hay had not been disturbed during the curing process.

The value of the hay as a feed was very low, as the few leaves that remained were gritty and bleached and the stems were very woody and coarse. The results show clearly what may be expected when the cutting of soy bean hay is delayed. The results of this plot are similar to those of plot I in field A except there is a greater loss of leaves and the leaves that did not shatter contained more grit. Curing the hay in the swath alone gave very poor results in both fields.

Plot 2:

Swath and windrow curing were used as outlined. The hay should have remained in the swath three days and windrowed on the fourth day. The hay actually remained in the swath five days and was windrowed on the sixth day, with one-half the windrow turned whenever conditions permitted. A large per cent of the leaves shattered when the hay was wind-

rowed, especially those on the lower side of the swath that stuck together. The hay on the lower side of the swath showed mold and some rot of the leaves, while the stems and beans were in better condition. The quality of the hay when windrowed was very inferior after being exposed to five days of damp weather in the swath.

One windrow was turned whenever conditions permitted or when such turning would hasten the curing process. The windrow was turned on the third, fifth and seventh days, being turned oftener due to the damp weather. A large per cent of the leaves shattered whenever the windrow was turned and by the end of the third turning a small per cent still remained. The exact leaf loss could not be determined but an estimate of 75% would not be too high. The over ripe condition of the hay when cut influenced the leaf loss to some extent. The unturned windrow soon developed mold and rot on the lower side and mold in the center resulting in an inferior quality hay.

The hay in the turned windrows was a little superior to the unturned but in neither case was it of value as a feed. There was shattering of the leaves, mold and rot developed, the leaves were gritty and the general quality of the hay was low. The results secured by this method were similar to those in field A, except there was more shattering of the leaves and the quality of the hay was of a lower grade. The hay in neither case was of any value as a feed.

Plot 3:

The procedure was a repetition of plot 2. The sampling of the hay for moisture determinations, turning of the windrows and all phases were done in like manner and at the same time. A smaller per cent of the leaves had dropped as the stage of maturity was not as far advanced, however, a large per cent of the leaves were lost when the hay was handled. The hay at the end of the curing period was a low grade and useless as a feed the same as the hay in plot 2.

Plot 4:

The McNaughton system was used to cure the hay. The hay remained in the swath five days and was windrowed the sixth day. The hay was in poor condition when placed in the windrow, the lower side of the swath was wet and some mold and rot were present. There was shattering of the leaves when the hay was windrowed, especially those that had stuck together. The hay remained in the windrow one day and part was stacked on the seventh day. The top of the windrow was in good condition to stack while the lower side was very damp. The remainder was stacked on the eighth day, being damp and wet due to rain in the forenoon. The stacking was done as a test to determine how wet the hay may be stacked and still cure without loss. A smaller per cent of the leaves shattered when handled than in previous plots as the hay was not as mature.

Improper construction of McNaughton stack. The hay was not placed sufficiently high above the pole, giving a chance for the stack to leak. The stack is too wide at base and poorly capped.

Properly constructed McNaughton stack. The stack is well capped to prevent leaking, nearly cylindrical and is proper width or nearly so. The straw extending out beyond the beans prevents them from becoming wet.

The hay remained in the stack twenty eight days. The interior of the stack was examined at regular intervals during this period to determine the condition of the hay and in no case was the development of mold or decay found. There was no perceptible difference in the drying of the hay that was stacked when wet and the hay stacked when drier. The amount of grass present in the hay was negligible and did not influence the curing process. The stacks were examined very carefully after two heavy rains and no indication of leakage was detected. A small amount of the hay at the top of the stack was lost but no loss occured at the bottom.

The same conclusions may be drawn from this plot as in plot 4 of field A. The hay stacked where wet and drying with no loss indicates that the hay may be stacked with comparative safety when the leaves are wilted. This allows a quick handling of the hay so that it will not be damaged by damp weather. The quality of the hay was inferior since it was in very poor condition when placed in the stack but may have been used as a roughage.

Plot 5:

Swath and cock curing were used. The hay should have remained in the swath one day and cocked the second day. The rainy weather necessitated delaying cocking until the fourth day. The growth of soy beans was lighter than the preceding plots but was nearer the proper stage of maturity.

The top of the swath was dry when the hay was cocked but the under side was damp resulting in shattering of the leaves

Soy bean hay in Field B curing in the cock and McNaughton stacks. The hay in the background curing in the swath and windrow. Soy beans practically free from grass and weeds. Stack on the right is properly constructed, stack on left improperly constructed.

when the hay was raked but the amount of shattering was less than in previous plots. The cocks were smaller than those in plot 3 of field A as dampness was present and there was not sufficient grass to keep the hay from packing and allow a free circulation of air. The cocks were constructed so as to shed water.

The cocks were exposed to a large amount of warm damp weather which is undesirable for the curing of quality hay. Mold developed in the center of some of the cocks while others showed no evidence of mold due to either heating or leakage. The water shed varied, some cocks shed the water perfectly while others leaked badly, the reason for this could not be determined.

This hay was superior in quality to the swath cured hay or the swath and windrow but was not equal to the McNaughton. The method used in this plot could not be recommended as the quality of the cured hay was inferior and would make poor feed.

Plot 6:

The curing method as outlined was followed. The hay was placed in a two swath windrow as soon as cut and one-half the windrow turned whenever conditions permitted. The turning was done with the hay fork which does not cause the shattering of as large a per cent of leaves as the side delivery rake. The plot contained two windrows made as nearly alike as possible so that a direct comparison of the turned and unturned windrows could be made.

The unturned windrow soon developed mold in the center and mold and rot on the lower side. This condition arose before the hay was sufficiently dry to stack or store. A small section of the top side was in better condition but the leaves were bleached and poor quality. At the end of the curing period or when the hay was sufficiently dry to stack or store it was useless as a feed.

The loss of moisture from the turned windrow was slow but a little quicker than the unturned. The turning was delayed by the damp weather. The leaves shattered badly when the hay was turned, and the original position of the windrow could be easily determined by the large amount of shattered leaves. Mold and a small amount of decay developed on the lower side of the windrow when the hay was not turned for several days. The hay was superior to the unturned windrow but was useless as a feed at the end of the curing period.

The loss of moisture was slow, mold and decay developed, leaves shattered badly when the windrow was turned and a very inferior quality hay was produced.

Plot 7:

The hay was cocked immediately after cutting. The cocks were smaller than in plot 7, field A as there was no grass present and the leaves were green. The size of the cocks may be judged from the pictures. The water shed was nearly perfect, there being no loss of hay from leakage. Mold developed in the center of some of the cocks two days after cocking due to being too green when cocked. No mold

Soy beans taken from center of cock that was cocked immediately after cutting. Mold developed on the leaves, stems and particularly the beans. There is no loss of leaves, yet the hay is worthless due to mold resulting from early cocking.

developed in two of the cocks and the hay cured in good condition. The cause of this difference could not be determined as the cocks were similar in appearance. In every case the bottom of the cock and a section at the top was lost which was unavoidable. Cocking green soy bean hay that contains no grass immediately after cutting cured into poor quality hay.

Plot 8:

A tripod or rick was used to cure the hay. The material used to make the tripod was the same as the poles used in the McNaughton stacks. Three poles were fastened together at the top and spread out at the base in tent shape. Similar poles were fastened twelve to fifteen inches from the ground. Better results may have been secured if the poles had been nine feet instead of seven. The tripod would have held more hay and in better condition.

The stacking of the hay was delayed due to the damp weather, remaining in the swath two days and windrowed the third day. The windrows were turned the fourth day with the side delivery rake and stacked the sixth day. The shattering of the leaves and some mold present caused the hay to be inferior in quality when stacked.

The presence of a large amount of pusley delayed the curing in this plot. Pusley contains a high per cent of moisture and loses it slowly, having cured but little when the hay was stacked.

The hay when stacked was damp containing approximately the same per cent moisture as the hay stacked by the McNaughton

The rick or tripod method of curing hay. Five or six of these stacks are required per acre. The stack is tent shaped and air circulates up through the stack from the bottom.

method. One stack and one cock were used. There was not sufficient hay to make two stacks so that a check was not used but a comparison of the cock and tripod methods of curing were made under identical conditions.

The poor condition of the hay when placed on the tripod could not be expected to cure high quality hay. No mold developed and the hay dried with no evidence of leakage. The circulation of air up through the center prevented the development of mold.

Leakage at various places in the cock caused mold and decay to develop rendering the hay useless as a feed. The quality of the tripod cured hay was superior to the cock.

The results indicate that the hay may be placed in the stack when wilted and cure in good condition. Stacking the hay quickly after cutting to eliminate loss due to rain is advantageous at this season of the year.

Tables 2 and 3 and Figures 6 and 7 give the rate of moisture loss from the soy beans in the different plots during the curing period. A large number of moisture samples were taken in field A than in B.

Zero per cent moisture in tables 2 and 3 and figures indicates the moisture content of the hay after it had been stored for five months. Moisture determinations were made on fourteen samples March 13. The mean per cent was 12.73.

The hay in field A, cocked immediately after cutting, cured the slowest from the beginning to the end of the curing period. The binder cut hay lost moisture slowly but quicker than the cocked hay. There was little difference in the rate

of moisture loss in Plots 1, 2, 3, 4, 5 and 6. The results were varied some, losing moisture quicker at the beginning and slower at the end of the curing period.

The rate of loss of moisture is no indication of best curing method in field B. The hay in plot 2 cured at the most even rate and plot 3 cured slowest. The rate of moisture loss in fields A and B do not indicate the best curing method to follow to produce the highest quality hay.

Table 2

Rate of loss of moisture from soy bean hay.

Field A
Expressed as per cent moisture

(Zero per cent moisture is 12.73 per cent or air dry hay and is stage at which loss of moisture ceased.)

Date sample taken	9-11	9-15	9-17	9-19	9-21	9-22	9-24	9-27
Plot I	62.2	41.6	33.4	20.6	14.4	6.0	00.0	00.0
Plot 2	62.5	43.2	32.7	21.7	22.0	17.0	6.7	00.0
Plot 3	61.7	45.1	37.2	22.6	16.0	16.3	8.3	00.0
Plot 4	63.0	43.1	36.2	17.3	14.0	6.0	00.0	00.0
Plot 5	60.0	41.0	37.2	26.3	13.1	9.2	8.7	00.0
Plot 6	61.0	42.0	31.1	19.6	8.7	12.1	4.8	00.0
Plot 7	62.0	54.2	43.9	33.3	23.8	26.5	7.0	00.0
Plot 8	62.0	47.0	33.3	29.9	29.3	6.7	00.0	4.8

Table 3

Field B
Expressed as per cent moisture

Date	9-12	9-14	9-21	9-24	9-27
Plot 1	53.0	39.5	20.7	14.3	00.0
Plot 2	53.0	43.2	27.9	16.7	00.0
Plot 3	54.0	47.6	38.2	24.2	00.0
Plot 4	55.0	46.1	37.0	20.9	00.0
Plot 5	53.0	36.3	23.2	15.4	00.0
Plot 6	56.0	31.3	22.4	14.2	00.0
Plot 7	55.0	41.3	38.8	9.2	00.0
Plot 8	54.0	45.6	38.7	21.3	00.0

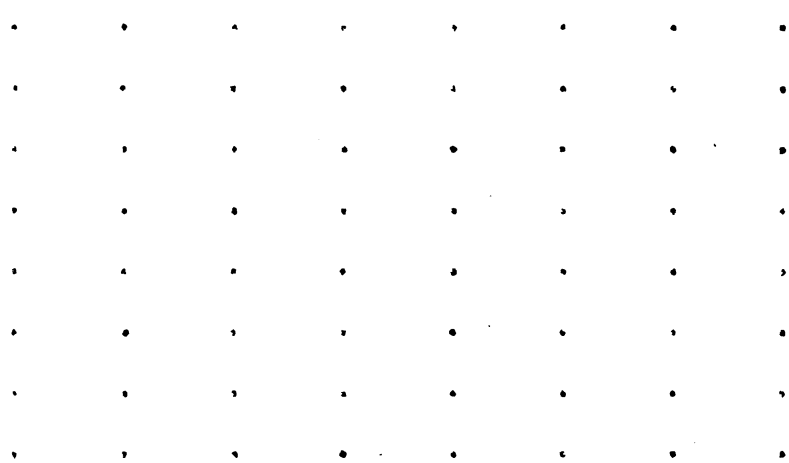


Figure 6

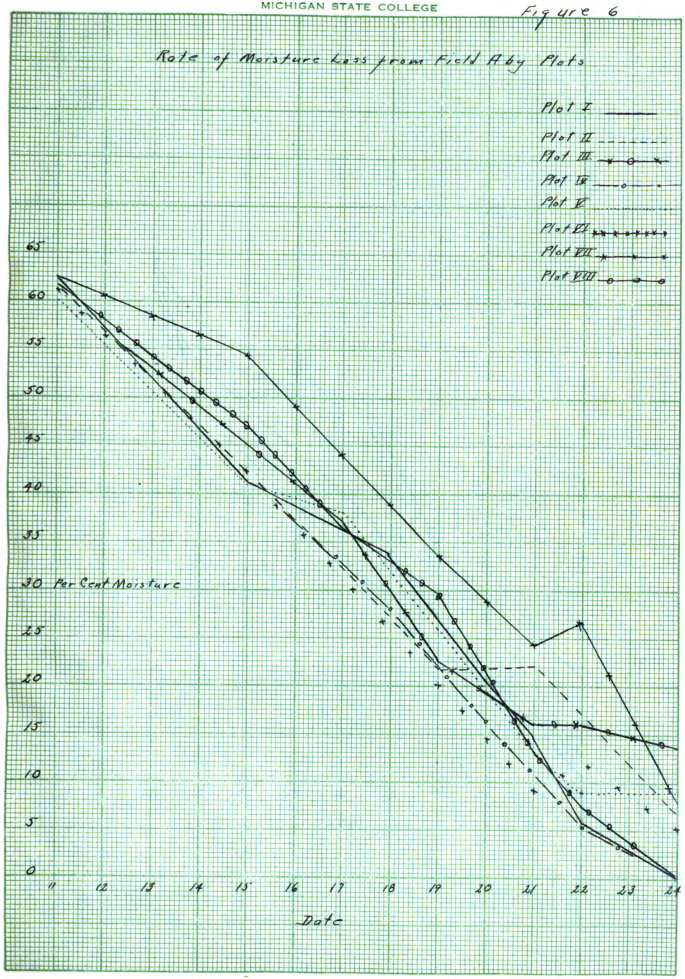
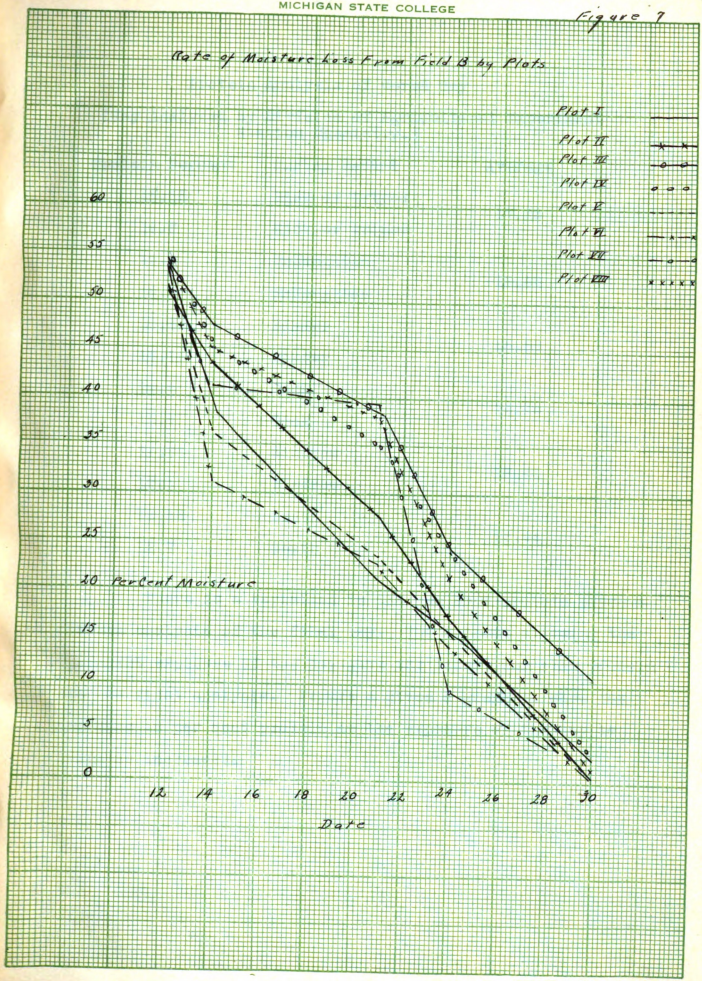

Rate of Moisture Loss from Field A by Plots
Plot I
Plot II
Plot III
Plot IV
Plot V
Plot VI
Plot VII
Plot VIII
65
60
55
50
45
40
35
30 Per Cent Moisture
25
20
15
10
5
0
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Date

Figure 7


Rate of Moisture Loss From Field B by Plots
Plot I
Plot II
Plot III
Plot IV
Plot V
Plot VI
Plot VII
Plot VIII
60
55
50
45
40
35
30
25
20 Percent Moisture
15
10
5
0
12
14
16
18
20
22
24
26
28
30
Date

Protein Analysis of Cured Hay

(Hay Analyzed by Division of Agricultural Experiment Station Chemistry.)

Protein Percent	Curing Method	Average
18.15	Rick or tripod	17.23
16.3	Rick or tripod	
15.6	McNaughton	15.45
15.3	McNaughton	
15.62	Binder	15.39
15.16	Binder	
14.6	Cock	14.25
13.9	Cock	
13.86	Windrow	13.48
13.1	Windrow	
13.18	Swath	12.94
12.7	Swath	

There is a variation in the per cent protein present in the analysis of the final hay. The methods allowing the greatest exposure of the hay gave the lowest per cent protein in the final analysis. Figure 4 gives a graph to show the decline in per cent protein as the exposure of the hay to rain is increased.

Figure 8

Protein Analysis of Cured Hay

Method of Curing

1 Rick or Tripod

2 McNaughton

3 Binder

4 Cock

5 Windrow

6 Swath

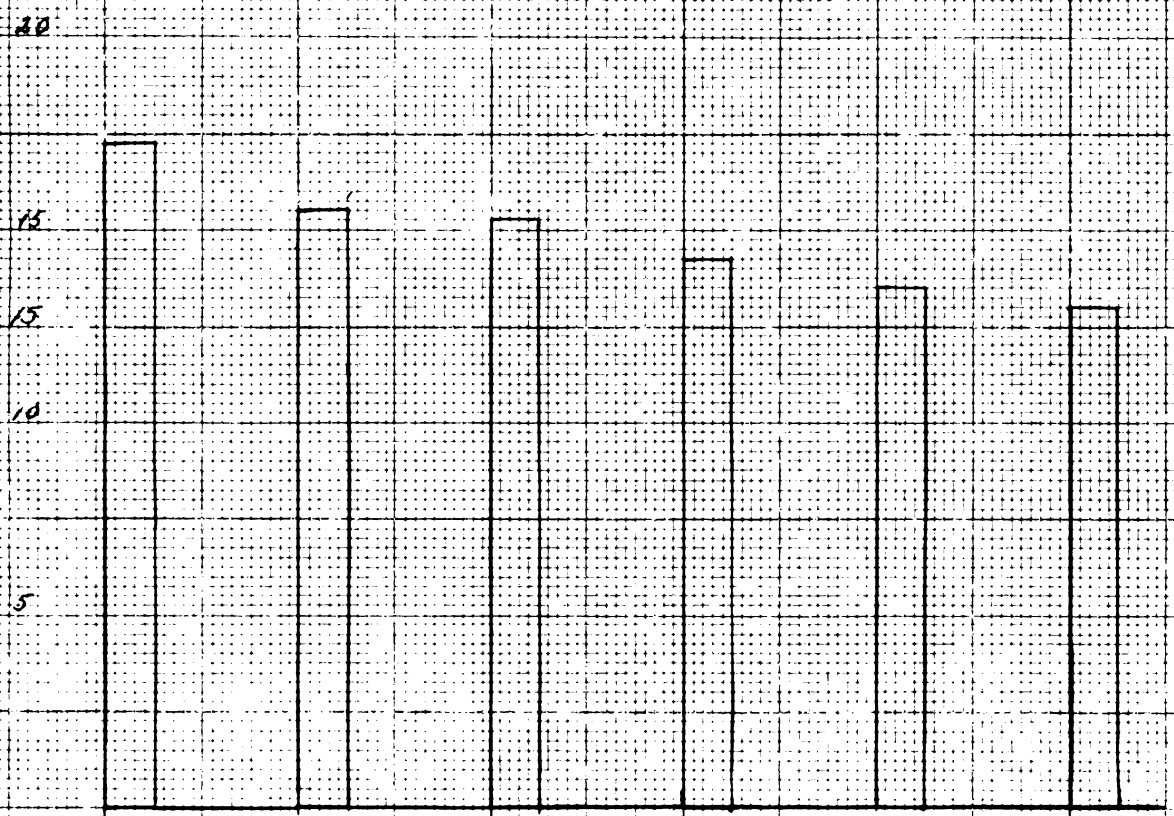


Table 4

Summary

Field A

Method of Curing	Plot	Final Quality	Rating
Cut with binder and stacked immediately	8	Very good	1
McNaughton	4	Fair	2
Cocked immediately	7	Poor	3
Windrowed immediately Windrow turned	6	Poor	3
Windrowed immediately	5	Very poor	4
Swath five days Windrow sixth day Cock seventh day	3	Very poor	4
Swath five days Windrow sixth day One-half turned	2	Valueless	5
Swath alone	1	Valueless	5

Field B

McNaughton	4	Fair	2
Tripod or Rick	8	Fair	2
Cock immediately	7	Poor	3
Windrowed immediately One-half turned	6	Poor	3
Swath five days Cock sixth day	5	Poor	3
Swath five days Windrow sixth day One-half turned	2	Valueless	5
Replication of Plot 2	3	Valueless	5
Swath alone	1	Valueless	5

CONCLUSIONS

1. The hay cut with the binder and cured in shocks containing six to eight bundles was superior to the hay cured by ~~either~~ any of the other methods. The soy beans free from grass retained the leaves and there was little loss during the curing process. The binder method is not practical where grass is present. The grass is generally tough, clogs the binder, and the hay will not be cut clean. Grass tends to hold the bundles open at the top causing a poor water shed. The bundles soon become damp on the inside and the hay is lost. The soy beans free from grass cut with the binder cured high quality hay under the adverse weather conditions.
2. The hay cured in the McNaughton and rick stacks was equal in quality and cured at the same rate. Hay cured by either of these methods may be stacked quickly after cutting, lessening the danger of loss from rain. The construction of the stacks is such that there is a free circulation of air through the hay. Grass aids in the water shed and circulation of the air. The quality was second to the binder hay.
3. Swath and cock curing combined produced an inferior quality hay. Partial swath curing increases the chances of the hay being damaged by wet weather. The presence of grass aided in the water shed and the ventilation of the hay in the cock. The hay was third in quality.

4. The hay cocked immediately after cutting gave varied results. A few cocks cured in good condition while the majority were poor in quality. The soy beans containing grass developed little mold but the green and clean soy beans molded in each cock and were lost. This method of curing gave very poor results.
5. The swath and windrow combined and the swath alone gave the poorest quality hay. A large per cent of the leaves were lost and the hay was gritty and useless as a feed.
6. A method of curing that will allow the handling of the hay so as to eliminate or reduce chances of loss due to rain will prove most efficient. The binder method was most efficient with the McNaughton and Rick second.

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