STUDIES ON THE UTILIZATION OF CORN PLANT BY-PRODUCTS BY BEEF COWS

by

Dale William Weber

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INTRODUCTION

Beef cattle production in Iowa and other corn belt states is in a state of change. The corn belt no longer has a monopoly on cattle feeding. Other regions of the United States are becoming major cattle feeding areas. In 1955, the Western and Southwestern states fed 32.5% and the corn belt area 67.5% of the nation's cattle. In 1968, the shares had changed to 41.4% and 55.8% (Ewing, 1969). With larger numbers of cattle being fed in other regions, it is harder for the corn belt feeder to compete for range feeder cattle, the traditional source of supply.

The Western states cannot appreciably increase the size of the cow herd due to feed limitations, so feeder cattle must be found elsewhere. By 1980, it is estimated that 32 billion pounds of beef will be needed annually. Therefore, 1.5 million cows should be added to the national beef herd each year (Ritchie, 1969).

Since beef cows are primarily roughage consumers, hay and grass is a natural source of feed. Wedin (1970) proposes that with maximum development and utilization of Iowa's 10 million acres of pasture and forage land, the beef cow population could be increased four fold or to 7 million head. There is still another 10 million acre source of feed with tremendous potential which to date has been utilized very little. This is corn harvest refuse, the subject of this paper.

It is a well-known fact that the beef cow is a relatively inefficient converter of feed to edible protein. Compared to other domestic species, the cow has a low rate of production. Dyer (1968) points out that the dairy cow, beef steer and pig are producing edible dry matter 37, 8 and 4 times faster, respectively than the brood cow. The cow has been able to compete because she utilizes low quality roughage for which there is little other use. A balanced ration is needed if beef calf production is to be profitable.

Because of the vast potential in the use of corn refuse to lower feeder calf production costs, the following objectives were considered:

1. To study the composition of the corn plant and to determine the contribution made by each component part to its total nutritive value.
2. To determine dry matter yields per acre of various harvested and grazed corn harvest refuse materials and to measure initial nutritive value and changes in value over the wintering period.
3. To measure under several management systems the utilization of corn harvest refuse by grazing beef cows.
4. To study performance and the requirements for supplemental protein and energy of pregnant beef cows and heifers wintered in drylot being fed harvested corn refuse materials.

The research discussed in this paper is not intended to be a specific work or a critical analysis of the subject of using corn harvest refuse as beef cow feed. This work is only a preliminary evaluation with the intent of establishing general guidelines of requirements using feed intake and cow performance as a basis for further detailed work.

LITERATURE REVIEW

There are very few reports in the literature on the use of corn-harvest by-products as feed for beef cattle. Articles can be found in popular agricultural magazines such as the Farm Journal, (Ritchie, 1969) concerning farmers and ranchers who have fed corn harvest by-products using various harvesting systems. However, the systems reported usually have not been conducted on a controlled experimental basis, and therefore, offer little information concerning actual nutritive value, improved or altered cow performance or cost analysis.

Energy Requirements of Beef Females

The level of nutrition afforded and the effects on the production and reproductive performance of the beef cow are basic to the study of any feedstuff. During the last decade, research has been conducted at several state experiment stations on the nutrient needs of the beef female during the various stages of growth and throughout the reproductive cycle. The objective of some studies has been to determine if the National Research Council (NRC) recommendations are correct for local conditions. Dyer (1968) points out that the cow's energy requirement is low and the basic problem in feeding the breeding herd is that of supplementation.

In considering a feed for beef cows, it is important to know how nearly it meets the energy, protein, vitamin and mineral requirements of the animal. As stated in the introduction relatively little work has been done using corn harvest refuse as the major feed source. Most of the studies have been with other forages including whole plant corn silage.

Hironaka (1970) noted the influence of weather conditions on energy requirements of beef cows. This work was conducted at the Manyberries Substation of the Lethbridge Research Station, Alberta, Canada. Cows were grazed on short grass range until drylot winter feeding began. Three rations designated as high (H), medium (M) and low (L) were fed to supply about 100, 80 and 60%, respectively, of the energy requirement as specified by the NRC (1963). Winter feeding was divided into middle and late pregnancy, and each group of 16 cows was assigned to one of the following treatments: HH, MH, MM, LH, LM and LL; and this continued for three wintering periods (1963 to 1966).

Weather influenced the amount of energy required to winter cattle. During the mildest winter, the cattle gained weight when fed at NRC recommended levels. During the most severe winter, the cows lost weight when fed at slightly above NRC levels. The author concluded with two important observations. In spite of weight losses by cows on the low level of nutrition, average birth weights of their calves equaled that of calves from cows on the high level of nutrition. Therefore the demand for energy of the developing fetus was met before the demand to maintain body tissues of the dam, even to the point where body tissue was lost.

The author stated that after the calf is born, the energy demand for replenishing body tissue appears to take precedence over the demand for milk production. Cows wintered on the low level tended to gain weight faster during summer grazing so that their weight by fall was nearly equal to the weight of cows on the high plane of nutrition. However, calves from cows wintered on the low plane of nutrition were consistently lighter at weaning.

As happens with much research, experimental results on beef cow energy requirements do not always agree. Jordan et al. (1968a) found in trials conducted in Eastern Canada that cows wintered according to NRC recommendations for digestible protein and total digestible nutrients (TDN) became excessively fat when later grazed on the usually adequate pastures of that region. Cows were wintered on four levels of energy for 4 years. Those wintered on the lowest level of nutrition consumed only 30% of the NRC minimum protein and energy requirements; however, they were also unable to make satisfactory recovery of weight on pasture during summer grazing. Jordan et al. (1968b) found that average birth weight and the 4-year average daily gain to weaning for the four levels of feed were significantly different ($P < 0.05$).

Researchers have noted the effect of energy level on reproductive efficiency. Christenson et al. (1967) at Nebraska studied the influence of pre-calving energy intake on post-calving reproductive performance of 2-year-old first-calf heifers. The main objectives were to determine the cause of the delayed interval from calving to first heat in heifers fed a low level of energy and to determine the pre-calving energy requirements. During the 140-day pre-calving period, one-half were fed at a high level which was 2.1 Mcal per 100 lb of body weight per day. The one-half on the low level were fed 1.36 Mcal per 100 lb of body weight. Intake of protein and other nutrients was similar for the two groups. All heifers were fed 3 lb of corn and a full feed of alfalfa hay following calving. Live weight gains during the last half of gestation were low, -5 lb and high, 78 lb and the average birth weights of the calves were low, 58.6 lb and high, 66.0 lb. Calves from cows fed high energy continued to gain faster, and this was apparently due to greater milk production of their dams. Heifers fed the high energy ration exhibited estrus sooner after calving (37.3 vs. 59.8 days).

Ingalls and Zimmerman (1965) had determined earlier that reproductive performance could be altered by feeding first-calf heifers at different levels of energy both before and after calving. The following statements are in agreement with their findings:

1. The energy level cows were fed after calving determined the number of cows becoming pregnant.
2. Energy level fed before calving changed the length of the interval from the start of the breeding season to conception.
3. A low level of feed either before calving or after calving resulted in fewer cows being bred early in the breeding season.

4. Conception rate at first service is lower in cows which are losing weight after calving or which are thin.
5. Cows on the low level of feed before calving do not show heat as soon after calving as cows on a high level of feed.

In other work at Nebraska, Clanton and Zimmerman (1970) found that the level of energy fed during the winter greatly influenced the interval between calving and the first heat. On the average, heifers fed a high energy ration came in heat 50 days following calving. Heifers that were fed a maintenance ration took over 140 days to come into first heat.

In a study of mature cows, Wiltbank et al. (1962) also showed that the level of energy intake influenced the length of interval from calving to first estrus, and the level of energy intake following calving influenced conception rate.

Extensive research has been conducted at Oklahoma State University to determine nutritive requirements of the beef cow. Ludwig et al., (1967) started with 8-month old heifer calves and carried them through seven calf crops. Four levels of energy were fed, ranging from low which gave no gain the first winter as calves with a loss of 20% of the fall weight during the following winters as bred females to very high which was the self-feeding of a 50% concentrate mixture each winter. Cows from all treatments were grazed on native pasture during the summer.

They found that average birth weights and percentage calf crop weaned were not significantly different. Average pounds of calf weaned favored the moderate and high levels, as opposed to the low and very high energy levels. A pronounced effect due to level of feed was in average calving date. Each step up in energy level advanced the calving date approximately one week. More cows on the low and moderate level of energy survived the trial period than did those on high and very high.

This work was followed by mature Hereford cows being individually fed in drylot (Ewing et al., 1968). From the results of feeding each cow through a yearly cycle involving gestation and lactation, it was concluded that the daily energy requirement for the mature non-lactating pregnant cow can be expressed by the formula DE (Mcal) = 5.669 + 0.00831 X live weight. TDN requirements appear to increase about 0.4 to 0.5 lb per 100 lb increase in cow weight. Or stated another way, the energy requirement to support the cow exclusive of milk production, increases at the rate of 7% for each 100 lb increase in cow weight (Ewing et al., 1967).

Ludwig et al. (1967) conclude their paper by advising that rather than to select a level of wintering for the life time of the cow, it would be better to give consideration to the life cycle feeding approach in which higher levels are fed during growth and development of the female followed by lower levels after maturity.

Corn Harvest Refuse Research

University of Illinois

To find ways of reducing feed costs for the beef cow owner, researchers at Illinois have been harvesting and ensiling stalklage since 1963 (Albert and Cox, 1968). Stalklage is defined as stalks, leaves, husks, and cobs. Each year of the study 5 to 6 tons of 50% moisture forage were harvested per acre. They estimated that one acre produced enough roughage to winter 2 cows for about 120 days. Their feeding trials in 1966-67 and 1967-68 showed that stalklage supplemented with soybean meal, urea or biuret was approximately a maintenance ration.

Because stalklage is low in protein, the Illinois workers studied the use of protein supplements added either before the stalklage was ensiled or when it was fed. Ensiling the supplements with the stalklage increased daily consumption and slightly improved digestibility of dry matter. This was particularly true when nitrogen supplements such as urea and biuret were used.

In the fall of 1964, cornstalks with approximately 56% moisture were harvested with an International forage chopper (Albert, Hinds and Lamb, 1965). One hundred pounds of a dried molasses product were added, along with metered water to make a 65% moisture silage. The cows consumed 30 lb of silage per day plus 1.5 lb of a 32% protein supplement. Rechopping of the forage for individual feeding increased consumption more than 15%. The cows had acceptable weight changes and produced calves of average weight.

Researchers at Illinois realized that when trying to utilize corn stalks for an economical maintenance ration the big barrier was a way to mechanically harvest the forage. Agricultural engineers working on the project concluded that the machine must be low cost, and that the forage harvesting operation should complement, not compete with, the harvest of shelled corn (Hunt and Stephens, 1968).

A conventional corn combine was converted into a corn forage harvester. It cut off the whole stalk, threshed and separated the grain and sent the rest of the corn plant through a chopper and then to a blower and into a trailing wagon. The authors estimated the costs for machinery and silo storage to be about 5 dollars per ton for a 70-cow herd. With corn yielding 100 bushels per acre, they have harvested 6 tons of forage at 50 to 55% moisture.

For some time Western wheat growers have been using a modified combine and trailing wagon to salvage the chaff and straw from the wheat harvest. University of Illinois researchers have used a similar machine to harvest an economical corn by-product cow feed called husklage. Husklage consists of cobs, husks and thrown-over grain.

Albert, Ferrell and Garrigus (1968) reported a trial they conducted which compared the nutritive value of equal amounts of dry matter from husklage, whole plant corn silage and stalklage. Each was supplemented with equal amounts of crude protein and vitamin A. Pregnant heifers were used in the trial and were limit fed 30 lb of the roughage daily (12 lb dry matter). The average daily gains on husklage, stalklage and corn silage were 0.73, 0.11 and 1.24 lb respectively. Differences in dry matter digestibility were 60.0, 55.4 and 65.0% respectively. No differences in calving performance could be attributed to ration effects. In this particular trial, 1,266 lb of dry matter per acre were harvested as husklage.

Iowa State University

One of the earlier trials reported in the Iowa State University research files on the value of cornstalk silage was conducted by Burroughs et al. (1954). The emphasis on this early study was on utilization of cornstalks by feeder cattle rather than breeding cattle. The objective was to reduce cattle feeding costs by using low grade roughage.

Burroughs et al. (1955) conducted an experiment during 1954-55 on the wintering of beef cows on cornstalk silage. They concluded that cornstalk silage with limited hay and minerals made a very satisfactory low-cost wintering ration for beef cows.

In 1958, Woods, Taylor and Burroughs (1958) reported that feed costs of beef cows were reduced by feeding corncobs and cornstalks.

Two years later, Ewing, Burroughs and Culbertson (1960) added different levels of ground corncobs to a basal ration of 50% corn silage and 50% oat-alfalfa silage. It was noted that the winter gains of pregnant beef cows receiving ground cobs were superior in all cases to gains of cows receiving an all-silage wintering ration. They felt that this points out the importance of dry roughage in rations of this kind and further indicated that the apparent quality of such added dry roughage may be of little importance if the ration is adequately supplemented.

From 1961 to 1965, several experiments were conducted at the Iowa Station using solid seeded corn, improved Sudangrass varieties, Sudangrass-forage sorghum crosses and hybrid forage sorghums for fall and winter grazing. It was found that a ration composed of solid seeded corn was a higher energy ration for beef cows than was actually needed. With the other forages mentioned above, the procedure was to harvest and stack a crop in midsummer and then to graze regrowth in late fall and early winter. The stacks were then self-fed when the majority of the standing forage had been consumed (Hunsley, Ewing and Burroughs, 1964; Vetter, Hunsley and Burroughs, 1965).

In these trials, a protein supplement was fed to the cows plus salt and a mineral mixture. All forages tested gave satisfactory results as measured by cow weight changes, calf birth weights and wintering feed cost. The grazing of broadcast corn was the most economical of the systems tried even though the cows tended to become overfat.

Stacking of forages with later grazing of regrowth increased carrying capacity 50 to 75%. However, it was pointed out that this does not necessarily reduce feed cost to the cows because of harvesting and stacking costs. It does insure an accessible feed supply in the event of periods of severe weather.

Since no other crop can usually compare with corn in TDN production per acre, most farmers want to produce as many acres of it as they can rather than grow such crops as Sudangrass. From 1964 to the present time, Iowa State has been conducting a series of wintering trials of beef animals using cornstalks or corn harvest aftermath.

The first attempt in utilizing this vast potential feed supply by grazing of beef animals was the winter grazing of 7-month-old heifers in 1964-65 (Hunsley, Vetter and Burroughs, 1966). Extra protein and energy were fed in the form of 2 lb of oats, 1 lb of a 32% supplement and 1 lb of alfalfa hay per head per day. The growth and development of these heifers was satisfactory as they gained 1 lb per head per day during the 140-day trial.

Wintering trials with pregnant beef cows and heifers on cornstalk grazing were conducted from 1965 to 1967 (Hunsley, Vetter and Burroughs, 1966; Hunsley, Vetter and Burroughs, 1967). Cows were stocked at the rate of one cow to 2 acres and were grazed for 112 days. The amount of corn available was estimated to be from 3 to 5 bushels per acre.

Because of open winters, no supplementary feed was necessary. The only feed charge for the two seasons was an average charge of 85 cents per cow per season for salt, minerals and vitamin A. Birth weights of calves born both springs were above the average weight of all the calves born at the Beef Nutrition Farm. The calves were healthy and vigorous. Few difficult deliveries were experienced. The dams appeared to milk well and they were rebred satisfactorily. During the first season, the cows gained 98 lb. During the 1966-67 season, the mature cows lost 2 lb while the first-calf heifers gained an average of 94 lb. The authors believed that the difference in response may be due to a greater efficiency of the heifers in converting feed and to a difference in grazing habits.

Conclusion

Since beef cows do not require a concentrated, high energy feed, the source of the feed supply for cows and heifers is not as important as is a knowledge of the feed's composition so that proper supplementation may be administered. It appears from the limited amount of research reported and from the studies of energy requirements of beef cows that corn harvest refuse can be adequately processed and nutritionally supplemented to successfully meet the energy needs of the beef cow.

EXPERIMENTAL PROCEDURES

The following described research was conducted at the Iowa State University Beef Nutrition Farm, Ames. Some of the trials reported are a continuation of previous studies mentioned in the literature review. A year around program on the feeding and management of beef cows has been the object of study over the years. Much useful and practical information has been collected, though much of it has not been published in scientific journals.

The experiments were conducted on the commercial beef cow herd using bred heifers and cows of all ages. The older cows were predominantly Hereford with some Angus-Hereford included. Two-year-old bred heifers used in the 1969-70 trials are approximately one-half Angus-Holstein and one-half Angus-Hereford. Since the treatments to be discussed involve only wintering trials, little information concerning the care and management of the cattle the rest of the year will be included. Except for some early weaning trials, most of the cows and calves were handled in a like manner during the summer months.

In all trials, beginning and ending weights are an average of two days' weights. As nearly as possible, all cows and heifers on trial were weighed regularly at 28-day intervals. Salt was available free-choice. In addition, unless fed a complete ration, cows and heifers had access at all times to a salt-mineral-vitamin A mixture composed as follows:

Ingredient	Percent
Salt	40
Trace mineral salt	20
Steamed bone meal	20
Vitamin A pre-mix (2.3 million IU of vitamin A/lb)	20
	100

Corn Plant Composition Study

A study was made of the composition of the corn plant. Whole corn plants were selected at random on September 28, 1968 and on October 4, 1969. The variety was Trojan's TX102 planted at a population of 22,000 to 24,000 plants per acre in 30-inch rows. The plants were divided into component parts; i.e., stalks, husks, leaves, cobs and grain. The composite of each component was chopped in a laboratory forage chopper to get representative samples. The samples were oven dried for 48 hours at 65°C to determine dry matter. After drying, samples were finely ground in a Wiley mill and stored for future analyses. In vitro digestible dry matter (IVDDM) determinations were made by the Tilley-Terry method and the modified macro-Kjeldahl laboratory technique was used in making crude protein analyses.

Cornstalk Grazing Studies

In this study an estimate of the amount of total dry matter available was made by collecting all vegetative material from five 50 ft^2 plots just prior to the beginning and again at the conclusion of the grazing season each of the 3 years. Samples were prepared and analyzed as was described in the corn plant composition study.

Cornstalk grazing trials with pregnant beef cows and heifers were conducted over three winter seasons. Data will be reported, also for the preceding 2 years (1965-1967). The same 40-acre field was used for all grazing trials.

For the 1967-1968 study, 10 mature pregnant cows and 10 coming two-year-old first-calf heifers were assigned to the 40-acre field at the rate of one animal to two acres for the 100-day grazing trial. No shelter was provided.

The cornstalk grazing study was continued in 1968-69 with one major change, a comparison of whole-field vs strip grazing. The 40-acre field was divided in half. Stocking rate was one cow per 1.67 acres. One-half of the animals grazed all 20 acres for the entire 120-day trial. The other 20 acres were divided into four, 5-acre strips. The cows were allowed to graze 5 acres initially. At the end of each 28-day weigh period, 5 acres were added to the grazing region.

The 1969-70 trial compared whole-field grazing, strip grazing and whole-field grazing plus husklage dumps. The whole-field and the grazing of strips were conducted as before. The husklage grazing field was a 15-acre field in first-year corn following several years of sod. To equalize field forage availability, cows in all three fields were allotted at the rate of one cow per 200 bushels of corn harvested. The harvesting procedure and machinery description can be found in the next section.

The husklage field was grazed as long as weather permitted or as long as grazing material was available. The dumps which were piled close together at one end of the field and which were fenced off with an electric fence were then self-fed using moveable head gates. Since cows in the husklage grazing field had some natural windbreak due to field topography, presence of a thicket and a board fence, cows in the whole and strip grazing fields were afforded a windbreak by the use of portable wooden bunker-silo sections.

Ensiled Corn Harvest By-Products

Experiment 797

The objectives of this preliminary wintering trial were to measure voluntary intake of unsupplemented corn refuse silage (CRS) and to compare resulting cow performance with that received by limited feeding of whole plant corn silage (WPCS) and by grazing of corn harvest refuse.

Whole plant corn silage was harvested in the conventional manner and stored in a gas-tight silo. The majority of the CRS was stored in a gas-tight silo, and the rest by vacuum packing which was accomplished by sealing the forage in an air tight plastic bag and removing the air with a tractor operated vacuum pump unit. Nine and one-half tons of 59% dry matter vacuum packed forage were harvested and stored on November 1, 1967. No water or preservatives were added to the forages at ensiling time.

The CRS was harvested by the Beefmaker I, an experimental machine designed by the Department of Agricultural Engineering. It was used to harvest 75 tons of CRS. The Beefmaker I had a cutterhead from a conventional forage harvester mounted on the front of a self-propelled combine. Powered stalk rolls below the stripper bars pulled the plant through the bars and snapped the ear. The ear was then conveyed into the combine and the remaining part of the plant was chopped and blown into a wagon towed alongside. While not completely successful because of low capacity and mechanical difficulties, the machine did satisfactorily complete the harvesting (G. Ayres, unpublished data).

Ten bred yearling heifers were assigned to the vacuum packed CRS test. They were group fed CRS ad libitum once daily. No supplemental protein or energy was fed. Ten mature cows and 10 bred heifers were assigned to a treatment of ad libitum feeding of gas-tight stored CRS. They were handled as described above. Ten other cows, three to ten years of age, were fed 40 to 44 lb per day of 32% dry matter whole plant corn silage. They were limit fed according to weight change response with no additional protein or energy provided. All cows were wintered in outside dirt lots with a high board fence for protection.

Experiment 808

The main objective of this experiment was to establish with feeding trials the type and amount of supplementation needed for satisfactory performance in beef cows and heifers using CRS as the basic ration ingredient.

Seventy pregnant cows and heifers were assigned to 10 lots with five ration treatments on the basis of weight, age and previous nutritional history. The 127-day trial was started on November 21, 1968. One replication of each treatment was penned in open dirt lots with a board fence windbreak. A replicate group was penned in lots with open-sided sheds for shelter. Corn refuse silage was fed *ad libitum* in all lots, and the animals were assigned to one of the following treatments in which daily supplemental feeding was as follows:

Ration	Pounds
No. 1	
Soybean meal	1.0
Rolled corn	0.7
Vitamins + minerals	0.2
No. 2	
Rolled corn	3.0
Urea-molasses supplement	0.5
No. 3	
Rolled corn	3.0
Vitamins + minerals	0.2
No. 4	
Rolled corn	1.5
Urea-molasses supplement	0.5
No. 5	
Rolled corn	1.5
Vitamins + minerals	0.2

The corn refuse was harvested between September 27 and October 21, 1968. A 5-row adapted combine that simultaneously shelled the grain into a hopper and delivered the whole stalks, cobs and husks into a windrow served as the harvesting machine. A field chopper picked the material up from the windrow and chopped it into a trailing wagon. At the silo, a recutter-blower equipped with a 1½ inch screen was used to rechop the material. No water or preservatives were added. One-hundred twenty two tons of total silage were prepared and stored in a 17 X 50 foot gas-tight silo and in a 17 X 50 foot concrete stave silo. It contained 2.2% protein as fed and 54% dry matter.

Experiment 828

The objectives of Experiment 828, which was conducted from November 23, 1969 to March 18, 1970, were to evaluate several corn harvest by-product forages and systems for their utilization. Cow weight changes, calf birth weights, and feed intake were used to evaluate the animal performance. The forage product was evaluated by total yield, dry matter yield, crude protein content, *in vitro* digestible dry matter content and harvesting costs.

Forty-eight coming first-calf heifers and 24 mature cows were allotted to four different forage treatments: husklage, whole plant corn silage, Beefmaker II CRS and Fox Forage Harvester stalklage. There were three lots for each treatment, one lot of cows and two lots of heifers, with six animals per lot. One lot of each treatment of the heifers was fed in open lots with only a high board fence for protection.

The cows on husklage and whole plant corn silage were in similar lots. The other lot of each treatment of heifers was kept in outside dirt lots with open-sided sheds for shelter as were the two remaining lots of cows.

Cows and heifers were allotted to pens and treatments as randomly as possible using the following criteria: age, previous summer treatment, breed, pregnant or open, and height:weight ratio. Wither height of all cows and heifers was measured when initial two-day weights were taken. A height:weight ratio was calculated by dividing the cow's wither height into her weight.

All cows and heifers were fed 0.5 lb per head per day of the Iowa-100 supplement:

Ingredient	Percent
Urea	37.5
Dicalcium phosphate	25.0
Dried molasses	17.5
Ground limestone	15.0
Vitamin A pre-mix (2.3 million IU/lb)	3.75
Trace mineral pre-mix	1.25
	100.00

Whole plant corn silage was limit fed. All other silages were fed ad libitum, and any that accumulated in the bunks was weighed back. Corn grain was added to some lots for extra energy as follows:

Treatment	Pounds of corn added per head per day	
	Bred heifers	Cows
Husklage		
11-23-69 to 12-21-69	5	3
12-22-69 to 1-23-70	6.5	4.5
1-24-70 to 3-18-70	8	6
Whole plant corn silage	0	0
Beefmaker II CRS	5	3
Fox stalklage	5	3

The whole plant corn silage (143 tons, 40.5% dry matter) was harvested from October 3 to October 7, 1969, and stored in a gas-tight 17 X 50 foot structure.

The Beefmaker II CRS was harvested from September 24 to October 17, 1969. The total prepared was 171 tons from 23.9 acres. Fifty-three tons were stored in a snowfence silo lined with moisture-proof paper, and 118 tons were stored in a concrete stave silo. The Beefmaker II was the only totally experimental machine used in this 3-year study. It utilized a forage harvester as the basic machine. An experimental snapping unit was attached between the gathering unit and the cutterhead. A cage-type shelling unit was attached above the cutterhead, and suitable conveying equipment was added to convey the snapped ear up to the sheller and to remove the shelled corn to a trailing wagon. Cobs were discharged back into the cutterhead and chopped refuse was blown into a wagon towed alongside with a second tractor (G. Ayres, unpublished data).

The Fox Forage Harvester is an experimental machine developed by the Fox River Tractor Company of Appleton, Wisconsin. It separates the grain and stalk harvest into two operations. It consists of a conventional flywheel type forage harvester with an experimental flail pickup. Fifty-four tons of stalklage of 53.5% dry matter were harvested from four different fields from November 3 to November 7, 1969. It was stored in a 17 X 50 foot gas-tight silo after being fed through a recutter-blower with a 3-inch screen (G. Ayres, unpublished data).

Husklage material was harvested by the Foster Harvest Master made by the Foster Manufacturing Company of Madras, Oregon. It was designed to harvest material discharged from the rear of the combine. It consists of two parts, an auger-blower mounted directly on the combine and a separate two-wheeled trailer with dump box. The auger with an integral blower on one end, was mounted under the rear hood of the combine. It collected the material coming from the pan of the combine and blew it into the trailer or wagon towed behind.

The Forage Harvest Master was used for two different harvesting and feeding systems. It was used on the 15-acre field described in the whole-field grazing plus husklage dumps section. Thirty-one dumps were collected from October 21 to October 24, 1969 averaging 1,757 lb of husklage per dump at 67.5% dry matter for a total of 27 tons of husklage.

Another 24.6 acres were harvested using forage wagons to collect the material coming from the blower. It was harvested from October 25 to October 29, 1969, and it was stored in a paper lined snowfence silo after being processed through a recutter-blower with a one-inch screen. A total of 38.6 tons of husklage of 67% dry matter was processed.

Approximately 1.5 tons of husklage were gathered per acre which contained 1.05 tons of dry matter.

Table 1 is a summary of the 1969 silage harvest.

Table 1. Summary of corn forage harvest, 1969, ISU Beef Nutrition Farm

Material	Type of storage	Total wet weight	Total dry weight	Average % dry matter	Average % grain
		(pounds)	(pounds)		
Beefmaker II CRS	Concrete stave silo	235,940	114,928	48.7	19.35
Beefmaker II CRS	Snowfence silo	106,340	47,989	45.1	11.07
Husklage from Foster Dumps	Dumps left in field	54,467	37,541 (31 dumps)	67.5	3.32
Husklage from Foster Harvest Master	Snowfence silo	77,271	51,602	67.0	1 ±
Stalklage	Gas-tight silo	108,126	57,830	53.5	1.33
Whole-plant corn silage	Gas-tight silo	285,500	115,704	40.5	24.98

RESULTS AND DISCUSSION

Corn Plant Composition

A 2-year summary of the percentage of dry matter, *in vitro* digestible dry matter (IVDDM) and crude protein contained by the component parts is presented in Table 2. At the time of collection there was a wide range of dry matter contained by the various parts of the corn plant, ranging from 32.7% for the stalks to 75.7% for the grain part. The percentage of IVDDM ranged from the cobs with 45.2% to the grain with 90.1%.

Table 2. Composition of parts of the corn plant at harvest[a], 2-year summary

Part	Dry matter %	IVDDM[b] %	Crude protein[b] %
Stalk	32.7	51.7	2.93
Leaf	72.5	54.1	6.16
Husk	65.4	63.2	3.29
Cob	55.7	45.2	3.59
Grain	75.7	90.1	9.64

[a]Average harvest date, October 1.

[b]Dry matter basis.

Figure 1 illustrates the proportion of the total plant that is made up by each component part at collection time. While the cornstalks contained 30.5% of the total wet weight and 16.7% of the dry weight, they only yielded 11.8% of the IVDDM and 7.1% of the crude protein. The grain portion assumes increasing importance when going from a wet to a dry weight and to an IVDDM and a crude protein basis. Cobs, husks and leaves maintain a relatively constant degree of importance. The decreasing value of the stalk when expressed on a dry matter or quality (IVDDM, crude protein) basis is evident. The leaves contain 12.3% and the stalk 16.7% of the total dry matter. This illustrates the variance in the quality of nutrients that are available to the cow who can selectively graze as opposed to the cow who is fed a silage product.

Cornstalk Grazing Trials

While it is not practical or safe to depend on the grazing of corn harvest refuse as the only source of cow feed for the winter months, 3 years of data have been collected to show what is potentially available and what kind of cow performance can be expected.

Pre-trial and post-trial samplings were conducted each year to determine (1) the quantity of feed available, (2) its initial composition, and (3) the change in composition over the winter season. Table 3 shows this information.

Pre-trial sampling indicated that an average of 340 lb of corn grain was available to the grazing cattle, and post-trial sampling indicated that very little remained. The 3-year average dry matter percentage changed from

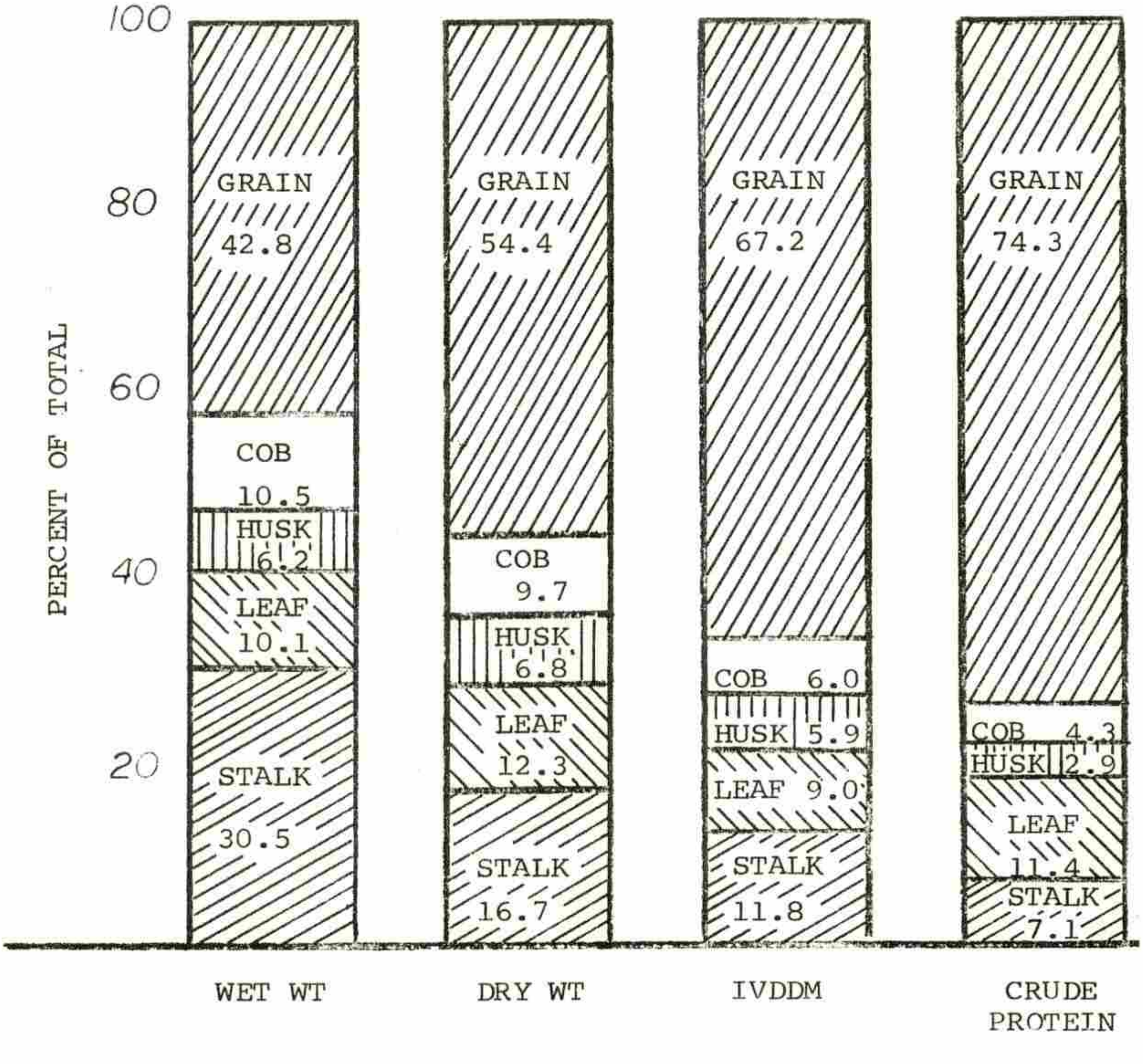


Figure 1. Parts of the corn plant as percent of total composition; average percent dry matter of whole plant at harvest, 60.9%; two-year average harvest date, October 1

Table 3. Three year composition summary of cornstalk grazing refuse

riety	Date of collection	Dry matter %	Dry matter per acre lb	Crude protein %	IVDDM %	Corn per acre lb	Harvested corn yield bu/A.
r 3206	12-3-67	67.0	6696	4.55	57.1	391	
TXS102	11-23-68	58.9	5314	4.37	41.5	210	
TXS102	11-8-69	71.2	6421	3.80	46.2	418	118
	Average	65.7	6144	4.24	48.2	340	
	Post-trial sampling						
	3-23-68	87.7	5142	3.65	50.9	?	
	4-23-69	91.0	3486	2.81	34.4	?	
	4-7-70	90.6	3945	3.47	41.7	?	
	Average	89.8	4191	3.31	42.3		

65.7% pre-trial to 89.8% post-trial. A drop of nearly 1% in average crude protein content and a drop of 6% in IVDDM from pre-trial to post-trial was also found.

Deterioration in the quality of feed over the winter is to be expected due to exposure to the weather. Barnes et al. (1968) studied the effects of weathering on in-field stored round fescue bales. The portion of the bale in contact with the soil, the outer shell of the bale, and the center portion of the bale decreased in IVDDM value 18.5%, 7.0% and 2.1%, respectively, from October through February.

Winter grazing trial, 1967-68

The winter of 1967-68 was open with little snow. Cows and heifers were wintered without supplemental feed. The only feed cost charged to them was for the salt-mineral-vitamin A mixture and for block salt. No accurate estimate of the consumption of this mixture was possible because weather proof feeders were not used. According to the pre-trial and post-trial samplings, 1554 lb of dry matter disappeared per acre during the course of the 100-day trial. This amounts to a daily allowance of 31.1 lb of dry matter per cow which is much more than an animal could consume.

It is difficult to account for the large loss of material. Sampling over the 3 years has been adequate to assume that a reliable estimation has been made. The excess loss must then be attributed to wind, trampling into the ground and leaching effects of weathering.

Figure 2 illustrates cow performance using weight change as the parameter of measurement. The graph shows the accumulated weight change over the 100-day wintering trial. During the first half of the trial, gains of 0.6 and 0.7 lb per day were noted for the cows and heifers, respectively. The estimate of over 6 bushels of corn grain that was in the field would have provided 6.7 lb of grain per cow per day (2 acres per cow) assuming that the grain was all consumed. Most of the grain would have been ingested during the earlier part of the test.

As the quality of the feed became poorer and more scarce, the mature cows were not able to maintain body weight though the 10 bred heifers continued to make slight gains. This difference in response between bred heifers and mature cows was also noted by Hunsley *et al*. (1967).

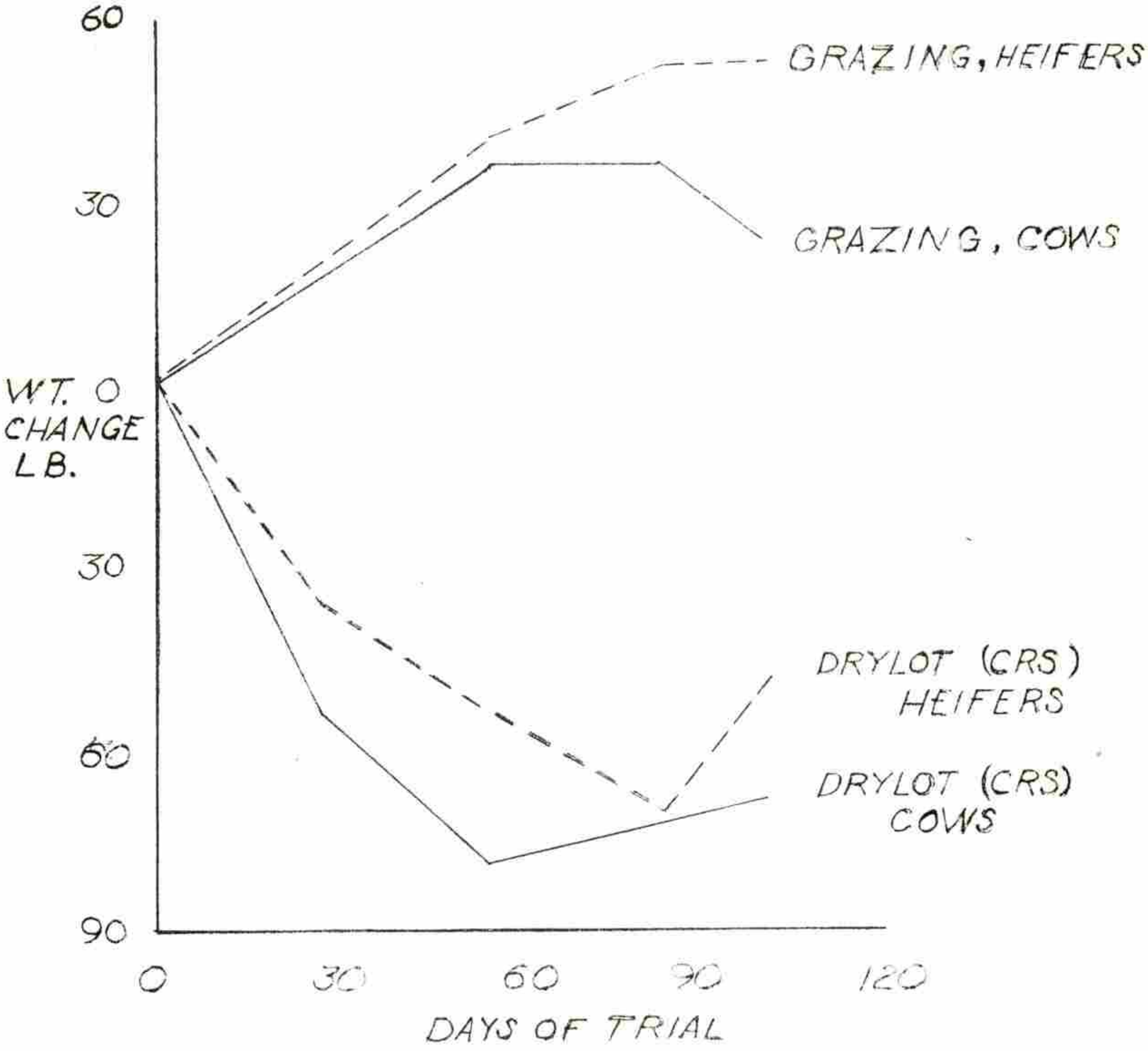


Figure 2. Average weight changes of pregnant cows and heifers grazing corn harvest refuse or being fed CRS in drylot, 1967-68

The wide difference in response between cattle grazing corn harvest refuse and those fed an unsupplemented corn refuse silage (CRS) is apparent from the graph as well. The CRS which was stored in the gas-tight silo was 40.8% dry matter, 4.59% crude protein, and 59.2% IVDDM. It was of acceptable quality; however, a finer cut may have made it more palatable. Weight losses of those fed CRS would have been more severe except that after 56 days on trial the cows and heifers on the CRS were fed 1 lb per day of a soybean meal and vitamin A supplement to help control the excessive weight loss.

One-hundred day weight changes of the cows on the whole-field grazing, limited whole plant corn silage, and partially unsupplemented CRS were 23.6, 58.8 and -66.6 lb, respectively. Calf birth weights averaged 76.2 72.4 and 74.6 lb, respectively. This supports the work by Hironaka (1970) which showed that cows' pre-calving nutrition apparently has little effect on calf birth weight.

Winter grazing trial, 1968-69

During the winter of 1968-69 several heavy snowstorms were experienced along with periods of cold weather so that grazing material was inaccessible. It was necessary to provide supplemental feed for 90 of the 127 trial days. Table 4 shows the average amount of hay fed per weigh period. Over the 90-day period an average of 13.7 lb of hay per day was fed.

From Figure 3 can be noted weight change patterns of cows on whole-field and strip grazing. There was little difference between the two

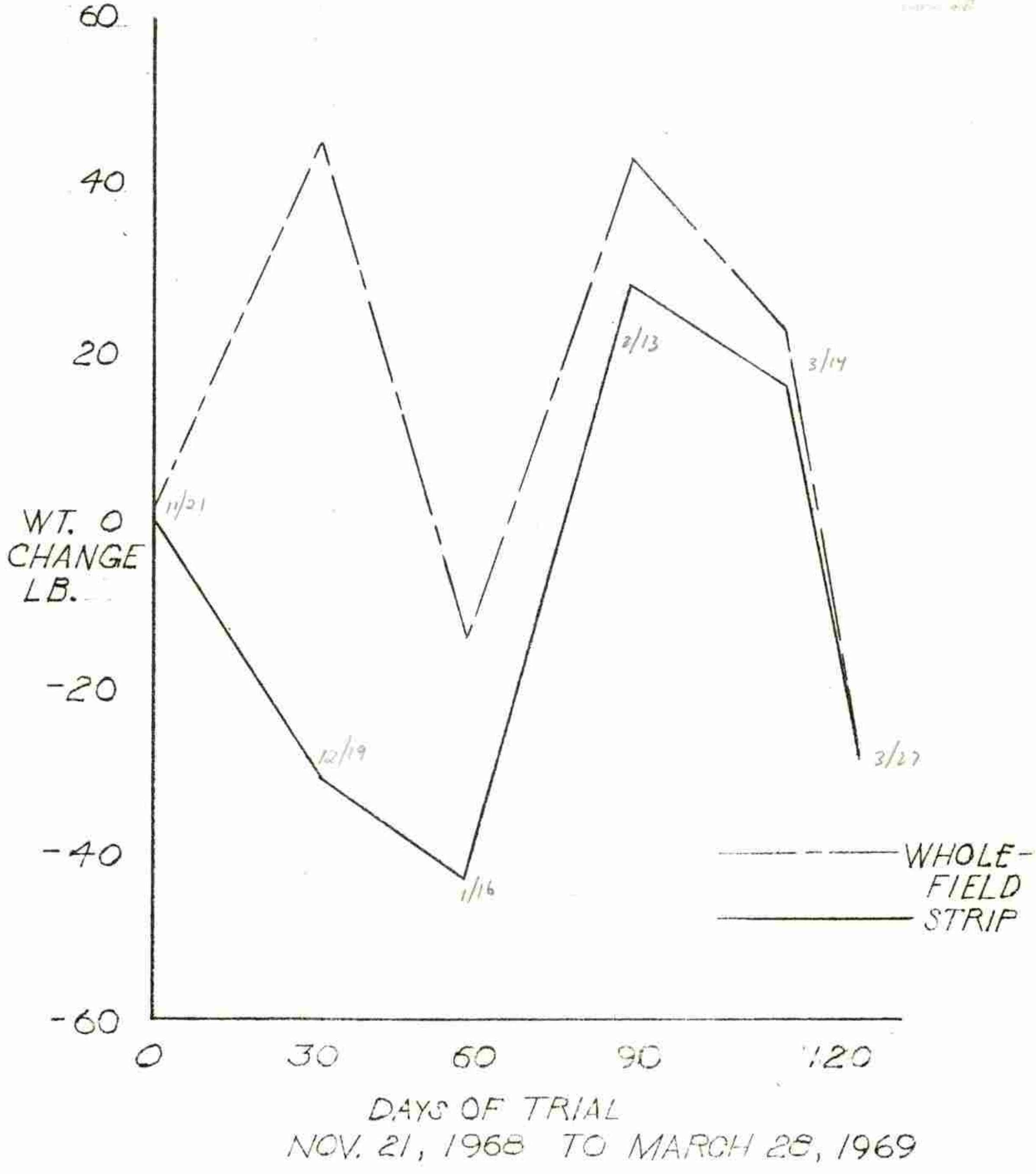


Figure 3. Weight changes of cows and heifers grazed on corn harvest refuse by whole-field and strip grazing

Table 4. Hay consumption during winter grazing trial by weigh period, 1968-69

	Weigh period					
	1	2	3	4	5	Average
	11-21 to 12-19	12-20 to 1-16	1-17 to 2-13	2-14 to 3-14	3-15 to 3-27	12-27 to 3-27
	28	28	28	28	13	
Hay, lb per head per day	0	7.8	18.4	14.7	5.9	13.7

trials in 127-day weight changes. However, the difference in response during the initial 28-day period is apparent. Cows on the whole 20 acres apparently gleaned the field very selectively and consumed the more palatable and nutritious grain and leaves. Since each group was fed equal amounts of hay during the remainder of the winter, and since overall performance was nearly equal, it can be assumed that the strip grazing cows derived some benefit from material that was made available to them later.

Pre-trial and post-trial sampling during 1968-69 indicated a net disappearance of 1,828 lb per acre (Table 3). The average birth weight of calves born to cows on strip and whole-field grazing were 67.2 and 66.9 lb, respectively. Calves born to cows in drylot being fed a supplemented CRS weighed an average of 68.5 lb.

Winter grazing trial, 1969-70

This grazing trial was a continuation of the previous year's study of whole vs strip grazing. Grazing of the field from which the husklage was gathered plus the feeding of the gathered dumps was an added system. Because

Plate 1. "An estimate of the amount of total dry matter available was made by collecting all vegetative material from five 50 ft^2 plots just prior to the beginning and again at the conclusion of the grazing season."

Plate 2. "Because of heavy winter snows, it was necessary to feed hay to the cows on the whole and strip grazing fields."

of heavy winter snows, it was necessary to feed hay to the cows on the whole and strip grazing for 70 days of the 114-day trial. When needed, hay was fed an average of three times per week. Over the entire 114-day trial 8.3 lb of hay were fed per head per day. For the 70 days of actual hay feeding, 13.5 lb per day were fed.

Cattle on the husklage field grazed only the cornstalk refuse for the first 20 days of the trial. After the first moderate snowfall, the cattle were allowed to self-feed on husklage dumps, but hay was never fed. Head gates were moved forward approximately two times per week or whenever it appeared that the cattle had consumed the majority of accessible feed. No attempts were made to measure actual consumption, but it appeared that the cattle ate most of the husks and leaves in the piles but refused a majority of the cobs. Cobs were in large pieces with many of them being whole.

Thirty-one husklage dumps containing a total of 37,541 lb of dry matter were available to the 13 cows and heifers. This was a total amount of 2,887 lb per cow for the wintering period. There was wastage due to refusal and to portions being covered by snow drifts. Husklage dumps kept well with only occasional pockets of moldy material being observed. The cattle appeared to find it palatable, but they also continued to graze the field area when there was little snow cover.

During the last 22 days of the trial, a urea-molasses supplement was top-dressed every other day over the husklage dumps at the rate of 2 lb per head per day. This supplementation appeared to increase palatability of the material, but no measurements were attempted. Composition of the supplement was:

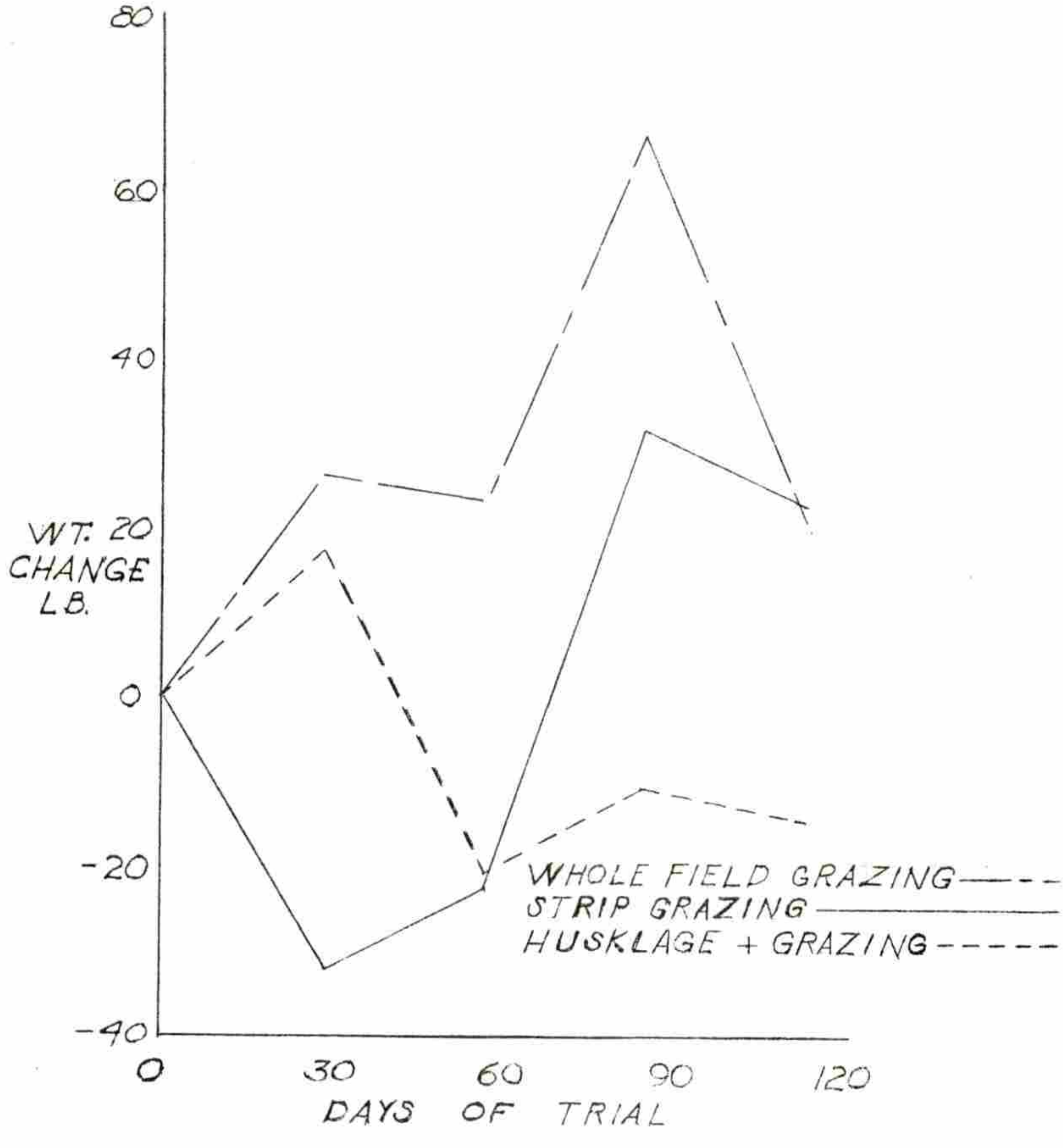


Figure 4. Weight changes of cows grazing corn harvest refuse, 1969-1970

liquid molasses	50 lb
water	45 lb
urea	5 lb

Figure 4 shows the weight change pattern of the cows on the three grazing treatments. The influence of the availability of more feed is noted in the first 29-day period. Cows on the strip, whole-field and husklage grazing had a net weight change of 22.0, 29.0 and -15.0 lb, respectively.

Even though 1.2 tons of dry matter were removed per acre from the husklage field, cows still out-performed the others when strictly grazing. This was attributed to the excellent nature of the corn refuse available and to grass found in waterways. Influence of supplemental hay is seen in the 29 to 85 day period. Results of the decrease in availability and quality of the refuse material is observed in the last period. As in the preceding winter's work, the influence of the delayed availability of the grazing material is observed in the smaller amount of weight loss of cows grazing strips than the whole-field grazing cows during the last 29 days of the trial (-9.0 lb vs -47.0 lb). The grazing plus husklage dump cows nearly maintained their weight.

Pre-trial and post-trial sampling revealed a net disappearance of 2,476 lb per acre of corn refuse material (Table 3). This gives an impossible consumption figure of 36 lb of dry matter per cow per day, indicating large losses due to wind, weather and trampling.

Table 5 shows the daily consumption and cost of salt and mineral for the cows on the three grazing systems. Since weather-proof mineral feeders were purchased, this was the first year that accurate salt and mineral consumption records could be kept. There is no apparent explanation why the

Plate 3. "Husklage was harvested by the Foster Harvest Master.... designed to harvest material discharged from the rear of the combine. The dumps were piled at one end of the field...."

Plate 4. "After the first moderate snowfall, the cattle were allowed to self-feed on husklage dumps."

Table 5. Salt and mineral consumption during winter grazing trial, 1969-70

Treatment	Salt per day grams	114-day salt cost per cow cents	Mineral per day grams	114-day mineral cost per day cents
Whole-field	13.3	10	15.9	36
Strip	23.3	17	22.1	52
Husklage	15.3	11	14.8	34

consumption of both salt and mineral mixture was higher for the strip grazing cows than for those on the other treatments.

Table 6 shows average calf birth weight, post-partum weight loss, and the post-partum weight loss as a percentage of the cows' pre-trial weight. Though the percentage post-partum weight losses were higher for the grazing trial cows than for those of similar cows fed ensiled corn harvest refuse material in drylot, the losses were well within the acceptable weight loss range as proposed by Ewing _et al_. (1968). Calf birth weights were only slightly higher for the cows on the grazing trials than for the drylot.

Ensiled Corn Harvest Refuse Trials

Drylot trial, 1967-68 (Experiment 797)

Even though it had been determined that cows could be wintered successfully by grazing corn harvest refuse, only a minimum utilization of the material was realized (Hunsley _et al_., 1967). The objectives of this preliminary trial were to maximize utilization and to see if comparable cow performance could be had in drylot.

Table 6. Cow weight changes and calf birth weights, wintering trials, 1969-70

Treatment	Weight change November through parturition lb	Post-partum weight as percentage of fall wt %	114-day weight change lb	Calves average birth wt lb
Grazing				
Whole field	-126	-12.5	29.0	71.6
Strip	-84	-8.4	22.0	69.2
Husklage	-106	-10.2	-15.0	69.3[a]
Drylot - Heifers				
Husklage	-3.2	-0.4	78.5	65.1
W.P.C.S.	33.2	4.0	125.5	69.7
Beefmaker II CRS	22.2	2.7	127.5	67.3
Stalklage	-13.1	-1.6	87.5	70.8
Drylot - Cows				
Husklage	-94	-9.1	31.0	70.7
W.P.S.C.	-54.4	-5.3	55.0	70.8[a]
Beefmaker II CRS	-56	-5.4	91.0	72.3
Stalklage	-120	-11.6	20.0	74.3

[a]Twins were not included in calf average birth weights.

Table 7 shows the analyses of the forages as they were fed on a dry matter basis. Wintering weight changes and average calf birth weights for the 100-day trial using CRS as a harvested winter forage, limited whole plant corn silage and grazing of pregnant cows and heifers are shown.

Table 7. Forage composition, cow weight changes and calf birth weights, wintering trials, 1967-68

Item	CRS	WPCS	Vacuum packed CRS	Cornstalk grazing material
Dry matter, %	44.7	---	65.0	67.0
Crude protein, %[a]	4.59	---	4.38	4.55
IVDDM, %[a]	59.2	---	---	57.0
100-day weight change, lb				
Cows	-66.6	58.8	---	23.6
Heifers	-51.2	---	-3.6	52.1
Average calf birth weight, lb				
Cows	74.6	72.5	---	76.2
Heifers	58.3	---	67.1	72.7

[a]Dry matter basis.

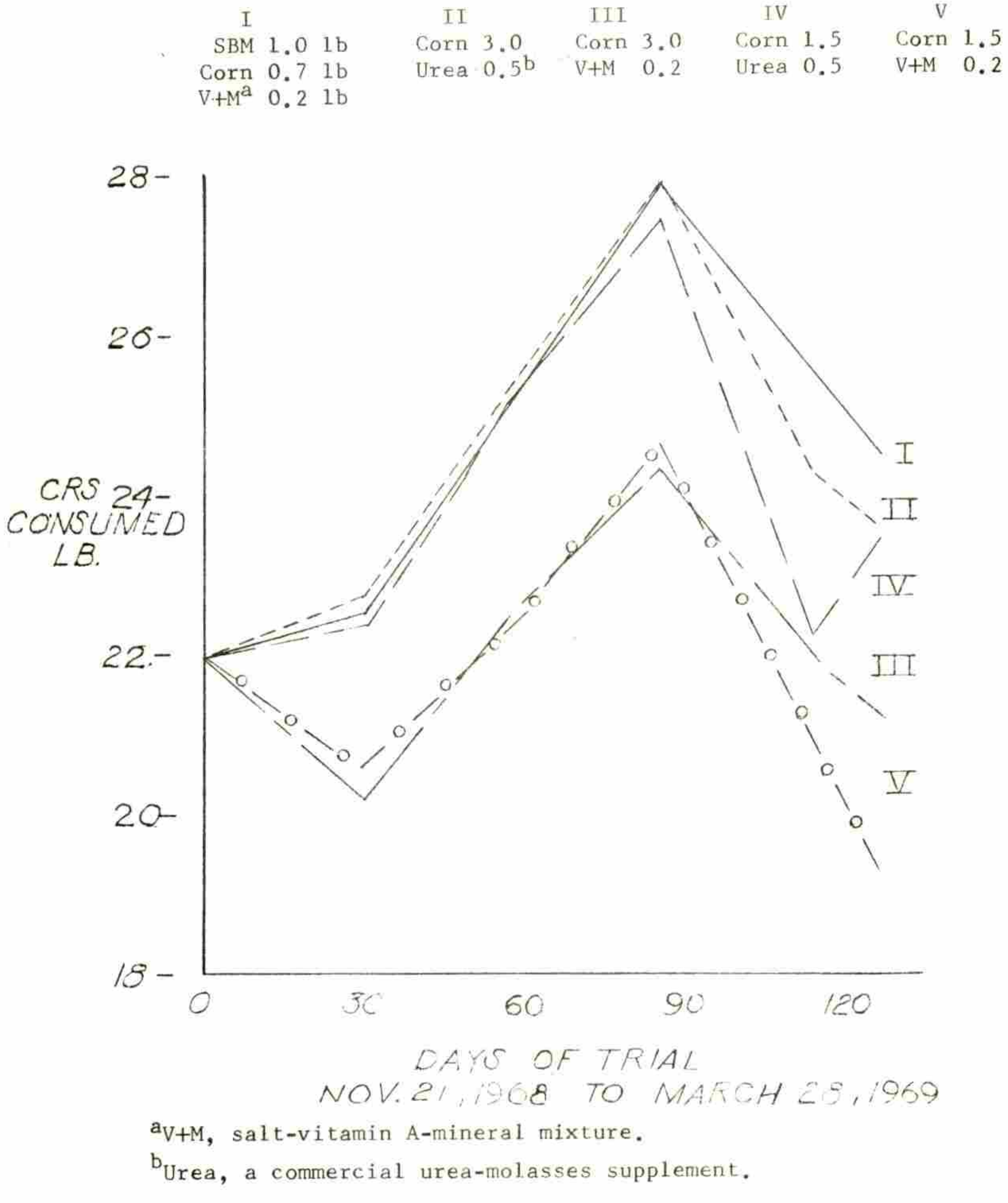
Bred heifer results on the vacuum packed CRS, the gas-tight silo stored CRS and grazing treatments do not give meaningful comparisons since the two drylot treatments were altered during the trial by the addition of protein supplement. The heifers were losing excessive amounts of weight and appeared unthrifty. Bred cows and heifers could not maintain body weight on the CRS without supplementation. After soybean meal was added mid-trial, slight weight gains were made and silage consumption was increased 4 lb.

The lack of a sizeable selection factor for cows fed CRS compared to cows grazing cornstalk refuse was likely an important factor in accounting for performance differences. Even so the cows tended to sort out the more coarse parts and ate the finer chopped forage first. Albert and Cox (1968) solved this problem at Illinois by rechopping the forage through a 3-inch screen.

Drylot trial, 1968-69 (Experiment 808)

The previous winter's trial had demonstrated that pregnant cows and heifers could not be wintered satisfactorily on CRS alone, and so a trial with energy and/or protein supplementation was designed. A successful supplementation program had been conducted at Ohio. Klosterman et al. (1966) wintered mature, pregnant beef cows successfully on chopped corn stover silage if it was supplemented with 10 lb of urea, 10 lb of pulverized high calcium limestone and 2 lb of dicalcium phosphate per ton added at time of ensiling. They summarized two wintering trials by concluding that stover silage was not equal to mixed hay but appeared to be a satisfactory wintering ration if properly supplemented.

Figure 5 shows the average daily consumption of CRS by weigh periods for the five treatments. The CRS as harvested contained 53.8% dry matter, 52.8% IVDDM and 4.31% crude protein. There was a marked increase in consumption from day 30 to day 85 followed by a sharp decline. An adjustment period at the beginning of the trial accounts for some of the later increase. It is not believed that the dry matter percentage or the quality of the CRS varied enough to account for these consumption differences. Weather is a factor



[a]V+M, salt-vitamin A-mineral mixture.

[b]Urea, a commercial urea-molasses supplement.

Figure 5. Pounds per day of CRS consumed by weigh period of cows on five supplementation treatments.

for some variation in intake. As shown by the graph, forage intake was directly related to the protein content of the ration. Rations I, II, and IV contained either soybean meal or urea. This supports the previous year's work which showed an increase in forage consumption when a protein supplement was added to the ration.

Figure 6 shows the accumulative weight changes of the trial animals during the 127-day period. The higher protein rations with the resulting higher CRS consumption gave weight responses indicative of the higher plane of nutrition. Treatments I and II showed a positive weight gain while III and IV indicated small losses. Treatment V with only 1.5 lb of corn grain added and no supplemental nitrogen was considered substandard for heifers and marginal for mature cows. Table 8 shows important cow weight changes and calf birth weight data.

Table 8. Cow weight changes and calf birth weights on five wintering treatments, 1968-69

	Treatment				
	I	II	III	IV	V
	SBM 1.0 lb Corn 0.7 V+M[a] 0.2	Corn 3.0 Urea 0.5[b]	Corn 3.0 V+M 0.2	Corn 1.5 Urea 0.5	Corn 1.5 V+M 0.2
127-day weight change, lb	38	51	-28	-18	-73
Weight loss, November through post-partum, lb	-119	-68.2	-172.6	-151.6	-175.9
Post-partum weight loss as percentage of fall weight, %	12.4	7.0	17.5	14.8	18.4
Average calf birth weight, lb	66.4	70.2	72.2	67.5	65.4

[a]V+M, salt-vitamin A-mineral mixture.

[b]Urea, a commercial urea-molasses supplement.

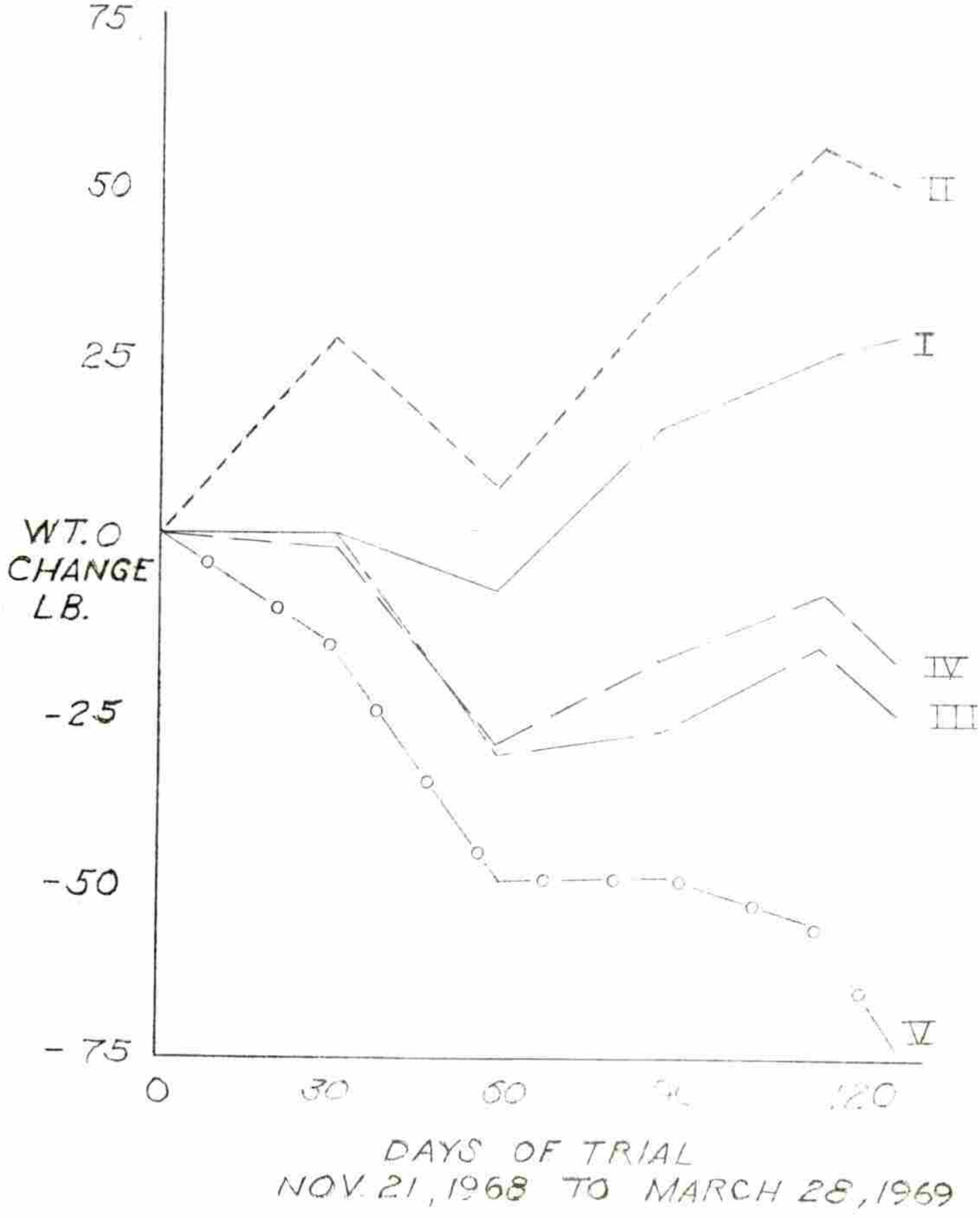


Figure 6. Average weight changes by weigh period of cows on five supplementation treatments, lb

November through post-partum weight losses for all treatments were within the acceptable range as reported by Ewing et al. (1968). Since some first-calf heifers were included in these trials, the weight losses were more severe than desirable on treatments III and V. Some of the younger dams had difficulty making the needed recovery while nursing a calf during spring and summer. The average calf birth weights, however, were all within an acceptable range.

It appeared from the results that the source of supplemental nitrogen was not important as long as enough energy was provided. The 127-day weight change for animals on soybean meal, urea plus 3 lb of corn and urea plus 1.5 lb of corn were: 38, 51 and -18 lb, respectively. This is in accord with the findings of Ewing, Burroughs and Simpson (1962). They found no consistent trends that would indicate that a soybean meal, a urea with ethanol or a urea-molasses supplement was superior from a nutritional standpoint.

Drylot trial, 1969-70 (Experiment 828)

Bred heifers require a higher plane of nutrition than do mature cows. The heifer is still growing as well as providing nutrition for the developing fetus. For this reason, the two classes were treated separately. This 114-day trial was a study of systems of harvesting, storing and feeding corn plant refuse materials.

The supply of Beefmaker II CRS which was stored in the snowfence silo lasted until February 10. The cattle were then fed the CRS from the stave silo. All silages were fed as indicated except during times of mechanical difficulties such as equipment breakdowns. Periods of sub-zero weather caused the gas-tight silos to freeze. This presents a real hazard if one is entirely dependent upon a gas-tight storage structure for the feed supply. Stalklage caused the most freeze-up problems which may be due to its low density. All forages kept well except for the snowfence silo stored husklage. It was too high in dry matter to ensile properly. When fed, it had a moldy appearance and a musty smell which probably decreased consumption. Table 9 gives important compositional data of the various forages.

Table 9. Composition of corn plant forages as harvested, 1969

Forage	Dry matter %	Crude protein[a] %	IVDDM[a] %
Whole plant corn silage (gas-tight silo)	40.5	7.07	67.3
Husklage (field dumps)	67.5	4.26	56.9
Husklage (snowfence silo)	66.8	3.72	56.1
Beefmaker II CRS (concrete stave silo)	48.7	5.97	61.8
Beefmaker II CRS (snowfence silo)	45.1	5.09	61.0
Stalklage (gas-tight silo)	53.5	4.35	50.8

[a]Dry matter basis.

Albert, Ferrell and Garrigus (1968) reported percentage dry matter digestibility using heifer digestion trials of the following forages:

Husklage	60%
Stalklage	55.4%
Corn silage	65.0%

Illinois husklage and stalklage were higher in digestible dry matter, but the corn silage was lower compared to the values reported in Table 9.

VanderNoot, Cordts and Hunt (1965) found that the protein contents of whole plant corn silage harvested at early dent and at late dent stages were 8.4 and 7.6%, respectively. These values are higher than indicated in Table 9, but the quality of the corn silage used in Experiment 828 was substandard.

Figure 7 shows cumulative weight change of cows and heifers wintered on the four forages fed in drylot. Cows and heifers in all treatments made positive weight changes. Least gains were made by the cows on the stalklage ration which indicated its lower quality. However, cows and heifers on stalklage delivered calves with the highest average birth weight as seen in Table 6. This supports the conclusions of Hironaka (1970) that the plane of nutrition of the pregnant cow does not have a great effect on calf birth weight. Other pertinent performance data of the cows and heifers are shown. All post-partum weight losses were within the acceptable range. Calf birth weights were average and a minimum amount of calving difficulty was experienced. Nearly all calves were healthy and vigorous, and the cows milked well as judged by the calves' performance. The breeding females may have been wintered on a higher plane of nutrition than was economically justifiable. Attempts were made to adjust supplemental feed to cows' response; however, 28-day weigh periods and extreme variability in weather conditions made it difficult to adjust intake to control weight changes when group feeding was practiced.

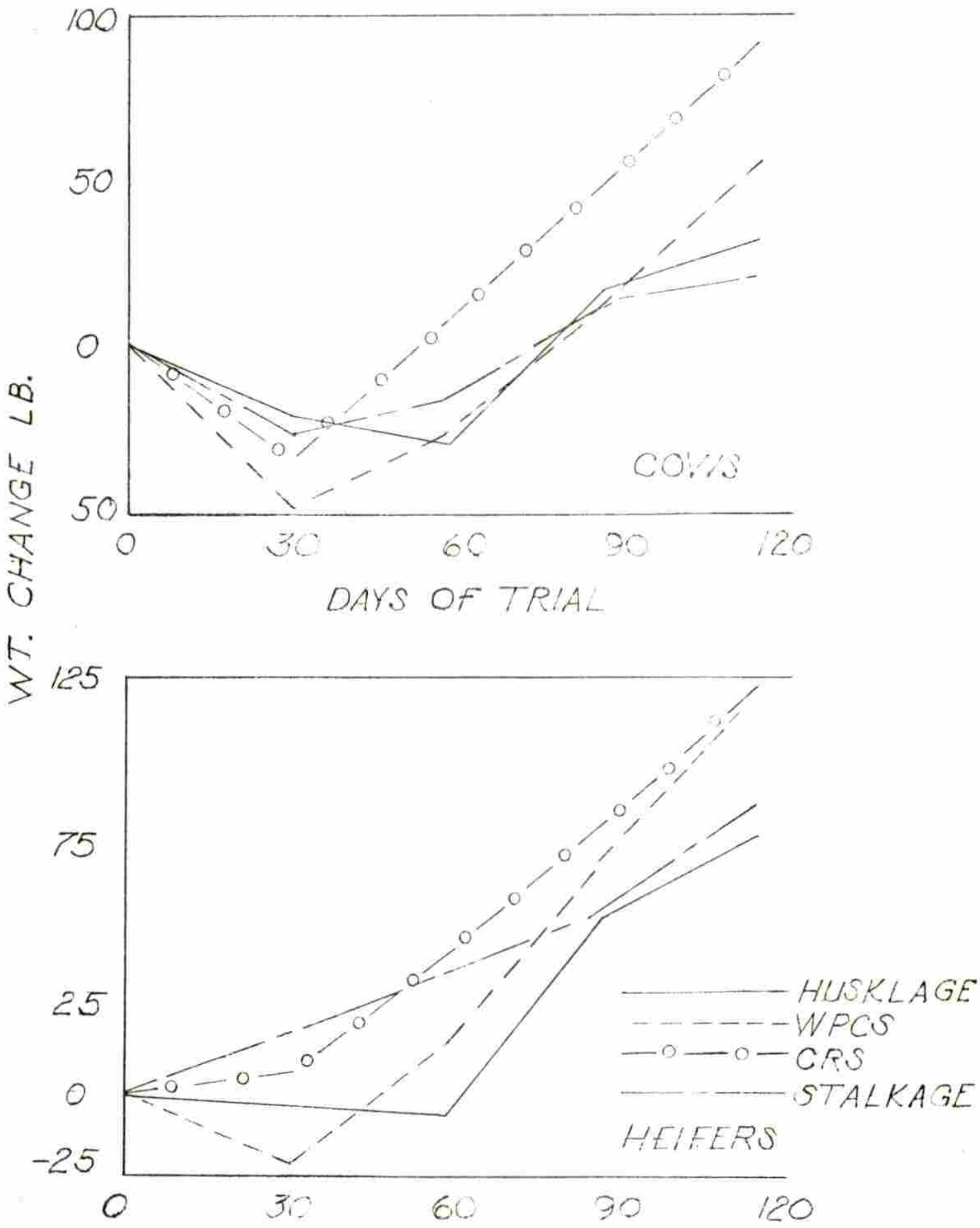


Figure 7. Weight changes of pregnant cows (upper) and heifers (lower) wintered on four forages, 1969-1970

Tables 10 and 11 show the intake of the harvested corn plant materials, corn, supplement and salt. All forages were fed *ad libitum* except for the whole plant corn silage which was fed at 30 lb the first 29 days and then at 35 lb for the remainder of the trial. Daily consumption of dry matter and digestible dry matter were not directly related to weight changes.

Accurate salt and mineral consumption records were kept for both grazing and drylot trials in the 1969-70 experiment (Tables 5, 10 and 11). The average daily salt consumption in drylot was 57.2 grams (range: 39.8 to 76.7) and for grazing 17.3 grams (range: 13.3 to 23.3), respectively. Part of the difference was due to the consumption of 17.6 grams of a mineral mixture containing 40% salt by the grazing cows. Still the drylot cows consumed about two times as much. The higher intake may have been due to the drylot cows being confined close to the salt block and to the grazing cows having access to some minerals from the soil.

Differences in feed requirements of heifers and cows can be observed in the whole plant corn silage treatment. On an average daily dry matter intake of 13.7 lb, cows and heifers gained 55 and 125 lb, respectively. The initial weights of the cows and heifers were 1037 and 823 lb, respectively. Some of the difference can be attributed to the cows' higher maintenance requirements. A cow's TDN requirements increase 0.4 to 0.5 lb per 100 lb increase in live weight (Ewing *et al.*, 1968).

When considering the 4 treatments, the total pounds of dry matter consumed was the least for the bred heifers on the whole plant corn silage, but their weight response was nearly the largest indicating a difference in quality of tested forages. The superior rating of the whole plant corn silage

Table 10. Summary of daily forage, corn, salt and supplement intake by cows fed harvested corn refuse forages, 1969-70

	Husklage	Whole plant corn silage	Beefmaker II CRS	Stalklage
Dry matter forage as harvested, %	67.0	40.5	45.0	53.5
Forage, lb	21.97	33.73	33.07	28.78
Forage dry matter, lb	14.72	13.66	14.88	15.40
High moisture corn, lb	4.84	--	3.00	3.00
Total dry matter, lb	18.25	13.66	17.07	17.59
Digestible dry matter consumed, lb	11.44	9.19	11.14	9.80
Supplement, lb	0.5	0.5	0.5	0.5
Salt, grams	71.0	65.3	45.4	76.7
Avg. 114-day weight change, lb	31	55	91	20

when considering IVDDM and crude protein content accounts for some of the difference, but there are other factors which have not been identified in this research.

Table 11. Summary of daily forage, corn, salt, and supplement intake by heifers fed harvested corn refuse forages, 1969-70

	Husklage	Whole plant corn silage	Beefmaker II CRS	Stalklage
Dry matter forage as harvested, %	67.0	40.5	45.0	53.5
Forage, lb	17.59	33.73	30.49	25.34
Forage dry matter, lb	11.78	13.66	13.72	13.56
High moisture corn, lb	6.65	--	5.0	5.0
Total dry matter, lb	16.63	13.66	17.37	17.21
Digestible dry matter consumed, lb	10.98	9.19	11.74	10.18
Supplement, lb	0.5	0.5	0.5	0.5
Salt, grams	42.6	68.2	39.8	48.3
Avg. 114-day weight change, lb	78.5	125.5	127.5	87.5

Plate 5. "The Beefmaker II was the only totally experimental machine used.... It utilized a forage harvester as the basic machine."

Plate 6. "All forages were fed *ad libitum* except for the whole plant corn silage."

GENERAL DISCUSSION

It is important in designing experiments to eliminate as many variables as possible. There was pen to pen variation in animal condition when using weight alone to allot cows. A height:weight ratio was a means to help eliminate this variable. Klosterman, Sanford and Parker (1968) found in work with Hereford and Charolais cross cows that there was a highly significant correlation between condition and height: weight ratio. It is known that there can be a 1000 lb fat cow and a 1000 lb thin cow depending on structure and body type. The height: weight ratio tends to put cows on an even condition basis. Whereas Klosterman et al. (1968) measured cows at the hooks, cows at Iowa State University were measured at the withers. After cows have been equalized on this basis, it may be that changes in weight may be just as good an indication of changes in condition as would be changes in the ratio (E. W. Klosterman, personal communication).

The simplest and least cost method for utilizing corn plant refuse is by grazing. According to Gay and Zmolek (1967), when cornstalk refuse is grazed, one-third of the total forage yield will be utilized, and a cow will consume 22 lb per day. This is a considerably higher utilization than the 10 to 20% calculated in the trials here from 1967 to 1970. Table 3 shows an average potential feed supply of 6,144 lb of dry matter per acre. With one cow to 1.67 acres there is a forage availability of 10,260 lb. A 120-day trial would give a daily feed supply of 88.5 lb dry matter. The average dry pregnant cow weighing 850 to 1050 lb should consume 14 to 16 lb of dry matter per day (NRC. 1970). This gives less than a 20% utilization figure.

Table 12 shows a 5-year summary of cornstalk grazing trials at ISU. Under conditions of relatively open winters, mature beef cows can efficiently graze cornstalks for a 100 to 120-day period with no apparent harmful effects on subsequent calving or reproductive performance. Because of the uncertainty of the winter weather, it is necessary to have a reserve supply of feed on hand. The harvesting of husklage dumps appears to be one way to provide this reserve supply of feed with a minimum amount of labor and equipment expense.

Cows grazing cornstalk refuse during open winters out-performed cows that were in drylot being fed an ensiled corn refuse material. Neither group was fed supplemental protein or energy. Since the drylot product was chopped and ensiled and fed <u>ad libitum</u>, one would conclude that the silage would be more palatable than the dry cornstalk material. All the causes of this discrepancy are not known. The cow's ability to selectively graze is a factor. The drylot cow has little choice as to what she eats; but the grazing cow can select the highly digestible and nutritious grain, husk and leaf material and by-pass the lower quality cob and stalk. This observation is substantiated by the weight change pattern of the grazing cow. She apparently eats the grain, leaves and husks early in the season as shown by weight increases. Since there are roughly 2 tons of dry matter left at the end of the grazing season (Table 3), the forage supply is not exhausted; however, by then weight gains have usually stopped indicating that the remaining forage is of poor quality and will not support

Table 12. Summary of cornstalk grazing trials (1966-1970)

Item	1966	1967	1968	1969	1970
Number of cows	12	20	20	24	24
Number of days	112	112	100	127	114
Weight change, lb	98	45	24	-28	12
Acres/cow	2.0	2.0	2.0	1.7	1.7
Feed					
Salt, mineral, vitamin A	+	+	+	+	+
Hay, lb/head/day	-	-	-	9.7	8.3

the cow nutritionally. In stalklage the stalk makes more than 50% of the total wet weight but only around 35% of the IVDDM and less than 30% of the crude protein. The corn refuse silage fed cow is forced to eat much low quality forage.

Maximum feeding value of corn plant refuse can not be realized unless it is harvested, processed, stored and fed. To date no completely satisfactory harvesting and storage system has been developed. Unless the corn refuse material contains a considerable amount of grain, it will not provide a plane of nutrition that will winter cows satisfactorily. A wide range of harvesting and storage costs for the various harvesting machines have been calculated by the Department of Agricultural Engineering.

Cows on an ensiled corn harvest refuse forage can be wintered adequately with a supplementary source of nitrogen either from urea or from a plant source if some grain is contained. The lower grade stalklage has required both nitrogen and energy supplementation. The range of dry matter consumption of drylot cows on Experiment 828 was from 13.7 to 18.2 lb per day which included up to 4.0 lb of grain.

Corn harvest refuse is a cheap source of feed, but it is an expensive feed if economical methods of harvesting, storing and balanced feeding programs are not developed. Quality and composition of refuse material is highly variable and will require different levels of protein and/or energy supplementation. Results have shown that bred heifers and mature cows should be maintained separately if each class's individual nutritional needs are to be met without over or under feeding the other.

SUMMARY

Wintering studies with pregnant beef cows and heifers were conducted over a 3-year period (1967-1970) to determine composition and utilization of corn harvest refuse. Three grazing systems were studied: (1) whole-field, (2) strip and (3) whole-field grazing plus the feeding of husklage dumps. Grazing was a satisfactory way to winter mature, pregnant beef cows during open winters with a stocking rate of not more than one cow to 2 acres or to an acreage equivalent of 200 bushels of harvested corn for a 3 to 4 month period. Strip grazing had the added advantage of supplying the cow with a more uniform supply of quality feed over the entire winter. Husklage dumps provided a low cost supply of reserve feed for periods of severe weather.

The utilization of corn refuse materials harvested by experimental and commercial machines was studied in drylot trials. Pregnant cows and heifers fed unsupplemented corn refuse silage (CRS) suffered severe weight losses of up to 1 lb per day. Good wintering results were secured when a urea or a soybean meal supplement was added to CRS. Energy and protein both appeared to be limiting in a corn refuse material devoid of corn grain. Husklage, CRS, stalklage and limited whole plant corn silage (WPCS) all gave satisfactory cow performance as measured by cow weight changes and calf birth weights when supplemented with protein and/or energy. Each product was different in percentage of dry matter, crude protein and _in vitro_ digestible dry matter and needed to be supplemented accordingly.

Composition studies of the whole corn plant and of the corn refuse materials were made. The amount and composition of grazing materials were

determined by pre-trial and post-trial sampling. Approximately 15% to 20% of the total dry matter available was utilized over the 100 to 127-day grazing trials. Quality of the dry matter decreased from pre-trial to post-trial which indicated selective grazing by the cows and effects of weathering. Determinations of the percentage contribution of each component part of the corn plant to total composition were made. Grain contained 67.2% and 74.3% of the IVDDM and crude protein of the total corn plant, respectively, whereas the stalk, which is the bulk of the stalklage contained only 11.8% and 7.1%, respectively. These findings contributed to the understanding of the varying weight changes of cows that were wintered by grazing compared to those fed harvested corn refuse in drylot.

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