

DROUGHT STRESSED SOYBEAN
SUPPLEMENTATION FOR BEEF COWS

By

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DROUGHT STRESSED SOYBEAN
SUPPLEMENTATION FOR BEEF COWS

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CHAPTER I

INTRODUCTION

Economic efficiency of a cow/calf operation is dependant upon many factors. Reproductive efficiency and the costs associated with maintaining a beef cow are major components in determining profitability of the cow herd. Approximately 70 percent of the energy required for beef production is used by the cow herd. Additionally, approximately 70 percent of the energy required by the cow herd can be associated with energy costs for maintenance. Hence, approximately 50 percent of the total feed energy required for beef production is associated with energy costs for cow maintenance (Ferrell and Jenkins, 1984). With an impact of this magnitude, it is obvious that there is a continuous need to develop management systems that result in reduced input costs and improved reproductive efficiency. Alternative feedstuffs should always be considered when opportunities arise. Whole oilseeds have been shown to be a cost effective, convenient approach to deliver dietary protein and lipid and have been used to increase reproductive performance in beef females (Bellows et al., 2001). The protein and fat content of soybeans potentially allow them to become an effective supplement to cows grazing low quality forages, with possible reproductive benefits from the added dietary fat. Drought stressed soybeans with slightly reduced nutrient levels could potentially be an effective supplement at a reduced cost. Dependant upon year, damaged beans sometimes have limited marketability and could potentially be better utilized as

supplements for beef cows. Cattle producers should consider opportunities to incorporate soybeans into their feeding programs when the soybean market is depressed or when damaged soybeans are available at low prices. Another question involves the processing of soybeans, including the advantage or disadvantage of cracking the beans before feeding.

CHAPTER II

REVIEW OF LITERATURE

Supplementation of Beef Cows

Meeting nutrient requirements of a pregnant or lactating female is of critical importance in assuring peak reproductive performance. These requirements include protein, energy, minerals, vitamins, and water. The common practice is to provide a beef cow with a supplement to meet her requirements while grazing low quality forages during these critical periods. Supplements are provided to grazing cattle to improve forage utilization, improve animal performance when forage supplies are adequate, or to provide additional nutrients when forage supplies are inadequate (Lusby and Wagner, 1986). When spring calving cows graze warm season grasses, some of the most nutritionally demanding periods coincide with forage of very low quality. To optimize animal performance, one must enhance intake and digestion of these low quality forages via the provision of supplemental nutrients. Degradable intake protein (DIP) is generally considered to be the dietary component that is “first limiting” to the utilization of low quality forage. Therefore, a supplement with adequate amounts of DIP fed to ruminants consuming low quality forage generally promotes increased forage intake and flow of nutrients to the small intestine (Hannah et al., 1991; Lintzenich et al., 1995).

Beef cows wintered on dormant native range require energy supplementation when forage quality or availability are low or when energy requirements increase because

of environmental or physiological effects (NRC, 1996). Energy source has different effects on cow weight change and body condition score (**BCS**) during gestation vs. lactation, suggesting that responses differ with physiological status (Marston and Lusby, 1995). This change is most likely due to changes in dry matter intake that would alter the associative effects caused by the supplement. These response changes could also be present in a gestating cow, as rumen capacity decreases as the fetus grows. Certain aspects associated with pregnancy and lactation present difficulties in providing females with adequate nutrition. In particular, voluntary intake is often decreased in ruminants during late pregnancy (Forbes, 1986). Several researchers have reported decreases in voluntary intake during late pregnancy and have attributed this to decreased ruminal capacity as a result of uterine displacement of the rumen. Forbes (1969) reported a 42% decrease in volume of ruminal contents in ewes from mid to late pregnancy associated with an 88% increase in uterine volume. Vanzant et al. (1991) showed a 13% decrease in volume in pregnant vs. open beef heifers by water filling.

Supplements are generally referred to as protein or energy; protein supplements are generally 30% crude protein or greater and usually used to enhance intake and digestibility of low quality roughages. A proper balance of protein and energy, dictated by basal diet, is required to maintain profitable levels of production in cattle consuming low quality forages. Energy supplements are lower in protein (15-20% crude protein), are generally grain based, and tend to either maintain or more likely reduce forage intake. Grain based energy supplements generally have a substitution effect which is occasionally a goal of producers when forage quantities are limited. The degree of intake reduction is dependant on a number of variables; including: overall protein level in the

diet, amount of grain fed, frequency of feeding, and the time of day supplement is fed. Protein must be simultaneously increased when grain based supplemental energy is increased to reduce negative associative affects. Often inclusion of grain works both directions; at lower levels it can decrease intake and at higher levels the substitution factor, along with decreased digestibility, can actually decrease the total amount of energy available to the animal (Carey et al., 1993). Sources of energy other than grains have proven to be effective in some studies. Readily digestible fiber sources fed as energy supplements to ruminants have increased forage intakes (Orskov, 1991). Intake and utilization of low quality hay were not impaired by up to 3 kg/d of a soybean hull supplement (Martin and Hibberd, 1990).

In research designed to evaluate first limiting nutrients for grazing range cattle, it has been determined that protein, not energy, is generally considered first limiting in low-nitrogen, high-fiber forages when forage availability is not limiting (Wallace, 1988; Freeman et al., 1992). Supplements with adequate amounts of degradable intake protein (**DIP**) to ruminants fed low quality forage commonly promotes increased forage intake and flow of nutrients to the small intestine (Hannah et al., 1991; Lintzenich et al., 1995). Forage OM, total OM, digestible OM, and total N intake increased in a quadratic manner with increasing additions of supplemental DIP (Koster et al., 1996). The largest incremental response was observed with the first addition of supplemental DIP. The results from this study corroborated earlier findings in which forage intake increased in response to providing increasing quantities of “protein” supplements to ruminants fed low quality forages (Guthrie and Wagner, 1988; Stokes et al., 1988; Scott and Hibberd, 1990). A diminishing response of forage OM intake to higher levels of DIP highlights

the fact that the potential to stimulate intake via DIP supplementation is limited. (Scott and Hibberd, 1990; Koster et al., 1996). Owens et al. (1991) reviewed research regarding protein supplementation and suggested that improved performance resulting from protein supplementation was likely due to either increased digestible organic matter intake (**DOMI**) and (or) improved efficiency of ME use. Although the latter may be important, they reported that most research indicates that increased DOMI can explain the majority of the performance response to protein supplementation. Ellis (1978) and McCullum and Galyean (1985) suggested that improvements in voluntary intake of low-quality forages as a result of N supplementation frequently are associated with increases in the rate of passage and forage digestion. Previous studies have reported increased digestibility when N was supplemented to beef cattle consuming low-quality forages (Del Curto et al., 1990; Scott and Hibberd, 1990; Hannah et al., 1991; Koster et al., 1996). Both increased intake and passage rate result in a shorter retention time of OM in the rumen (Staples et al., 1984); therefore, less time is available for cellulolytic microorganisms to digest fiber. This results in a slight decline in NDF digestibility when higher levels of DIP are supplemented. Volatile fatty acid proportions are also altered with different levels of protein supplementation. Decreased acetate and increased propionate proportions have been observed with the addition of DIP supplementation (McCullum and Galyean, 1985; Hannah et al., 1991; Koster et al., 1996).

Recently, several studies have included the use of supplemental dietary fat to beef cows to enhance performance and reproduction. The primary reason for feeding supplemental fat is the increased energy density that occurs without increasing level of cereal grains in the ration (Coppock and Wilks, 1991). The greatest concern with feeding

extra dietary fat is its effect on intake and fiber digestion, and determining what level is beneficial without altering the rumen microbial population. Hess et al (2002) reported that feeding supplemental fat to beef cows during late gestation is a useful method to alleviate the negative impacts of prepartum nutritional inadequacy on reproductive performance. Lipid-based supplementation has not been used to a great degree in forage-based beef cattle diets, presumably because of potential negative effects of fat on fiber utilization (Jenkins, 1993).

Postpartum Rebreeding

The importance of prepartum nutrition on subsequent postpartum reproduction is well established (Randel, 1990; Short et al., 1990; Dunn and Moss, 1992). Failure of postpartum beef cows to rebreed after calving due to long periods of anestrus reduces reproductive efficiency (Wiltbank, 1970). Various research has shown that protein and energy intake has a significant influence on reproductive performance in beef cows (Randel, 1990; Short et al., 1990). The body condition scoring (BCS) system, as described by Wagner et al. (1988), is a useful indicator of empty body lipid composition. Body condition score is the single most important factor defined to date influencing the length of the postpartum anestrous period and pregnancy percentage in suckled multiparous cows (Selk et al., 1988). Postpartum interval can be influenced by pre and postpartum nutrition, body condition, suckling status of the cow, and dystocia (Houghton et al., 1990). The duration of postpartum anestrus can be reduced with proper nutrition and maintaining cows in adequate body condition. Extensive research links level of nutrition before calving to reproductive performance; therefore, the last third of

pregnancy of a spring calving cow becomes a nutritionally critical period that generally falls in the dead of winter.

Dietary Fat Supplementation to Beef Cows During Late Gestation

Nutritional programs based on optimal diet formulation are required to increase efficiency in beef cattle production. Adequate energy is required in the beef cows' diet to achieve good reproductive performance. Nutrition-reproduction interactions have been due to the effects of dietary energy, body energy reserves, and N balance on sexual maturation and post partum rebreeding performance (Kinder et al., 1987; Randel, 1990). Historically, an increased level of energy was obtained through inclusion of cereal grains which posed potential problems with fiber digestion. Fat is a dietary ingredient that is being thoroughly researched due to its energy density and possible enhancement of postpartum reproduction. Adding fat to a diet will alter fermentation in the rumen, and precautions must be made to not drastically decrease digestibility of non-lipid energy sources. Energy density of fats is greater than the ingredients they replace, resulting in increased energy consumption at physical capacity. Prepartum nutrition is very important to reproductive efficiency. It is difficult to effectively compensate for the reverse and negative impacts of prepartum nutritional inadequacy on reproductive performance through nutritional inputs postpartum (Lalman et al., 2000). Minimal reduction in postpartum interval can be achieved by increasing the beef cow's nutritional plane during lactation (Lalman et al., 1997). Staples et al. (1998) reported that the influence of diet on phospholipid pools of fatty acids may lead to carry over effects, which could influence subsequent reproduction of cows provided with supplemental fat during late gestation. Supplemental fat to reproducing beef cows may be used to regulate production traits

(Hess et al., 2002). The primary reason for feeding supplemental fat is the increased energy density that occurs without needing to increase level of cereal grains in the ration (Coppock and Wilks, 1991). Performance of calves born to fat supplemented cows is another area of interest; cold tolerance, birth weight, weaning weight and rates of gain have been measured in a few studies and will be later discussed in more detail. Previous studies have shown variable effects of fat supplementation on weight, body condition score, and reproductive performance of cows compared to those fed control diets. Several studies have shown positive effects of relatively short-term feeding of supplemental dietary fat to dams on cold tolerance of newborn calves (Lammoglia et al., 1999), ovarian follicular populations (Lucy et al., 1991; De Fries et al., 1998), increased conception rates (Lammoglia et al., 1997), and pregnancy rates (Grummer and Carroll 1991; DeFries et al., 1998; Bellows et al., 1999). Effects on rebreeding have been variable and may depend on type and time or duration of fat feeding (Grummer and Carroll, 1991; Carr et al., 1994; DeFries et al., 1998). A residual effect of prepartum fat supplementation on subsequent conception and calf weaning weights has been suggested by Bellows et al. (2001). In a review by Hess et al. (2002), four late gestation supplemental fat experiments were evaluated. Supplementation lengths were 59 to 68 d before calving. Percent cows cycling and first service conception rates were not affected by prepartum fat in all four trials, but Graham et al. (2001) reported that feeding whole soybeans to mature beef cows for either 30 or 45 d before calving increased first service conception rates (62.8 vs 85.7% and 62.5 vs 75%, respectively). When results of all four trials were combined, an overall 10.5% improvement in pregnancy rates was achieved for fat supplemented cows. Pregnancy rates increased from 56% for 89 control cows to 70%

for 179 fat supplemented cows where high linoleate safflower seeds were fed 53 or 55 d prepartum (Lammoglia et al., 1999a,b). Feeding high-oleate and high linoleate safflower seeds to primiparous beef cows 55 d prepartum increased subsequent pregnancy rates from 57% to 75 and 77%, respectively (Lammoglia et al., 1997a). Geary et al. (2002) reported prepartum diets high in linoleic acid increased calf weaning weight and heifer rebreeding performance. Animal response to supplemental fat appears to be dependant upon: body condition, age, nutrients in basal diet, and type of fat supplement. When adequate nutrients are available, the positive effects of supplemental fat may be masked (Bellows et al., 2001), and cows with body condition scores > 5 may not respond as well to fat supplementation as cows with lesser BC (Webb et al., 2001). Espinoza et al. (1995) reported that beneficial effects of fat supplementation on cow reproduction were found for cows with body condition scores ranging from 2.5 to 4.1. Appropriate situations for added dietary fat might be when pasture or range conditions are limiting, or when condition of cows is below desired level during critical periods.

Role of Dietary Fat on Reproductive Processes

Ingestion and flow of supplemental fatty acids to the small intestine may benefit reproductive tissues and aid reproductive performance independent of energy supply (Thomas et al., 1997; Williams and Stanko, 2000; Bellows et al., 2001). Added fat may have a physiological effect outside of its generally accepted role as a nutrient source that would bring upon metabolic changes to the animal, and plant derived oils have a greater impact on reproductive performance than do animal oils or calcium salts. Resumption of estrous cycles in postpartum beef cows is an important factor that affects a beef cow's productivity and the efficiency of a beef cattle production system. Failure of ovarian

follicles to reach mature size and ovulate, poor estrus expression, and abnormal luteal function are common problems observed during postpartum anestrus (Lucy et al., 1992a). The occurrence of short estrous cycles following first ovulation is a common observation during the early postpartum period in lactating beef cows (Short et al., 1990). Most of these first postpartum ovulations are not preceded by estrus, and their physiological significance is unknown. However, the increase in serum progesterone concentrations during the short estrous cycle is followed by resumption of estrous cycles of normal duration (Murphy et al., 1990). Fat supplementation may provide a means to more adequately meet dietary requirements by increasing circulatory proportions of major fatty acids (Filley et al., 2000; Whitney et al., 2000), and possibly affecting postpartum reproduction through changing concentrations of prostaglandin (Filley et al., 2000; Grant et al., 2002). Feeding cows supplemental dietary fat increased serum progesterone, serum and follicular fluid cholesterol concentrations, and the area occupied by lipids in the small and large luteal cells (Williams, 1989; Hightshoe et al., 1991; Ryan et al., 1992; Lammoglia et al., 1997). Fat supplementation has stimulated ovarian follicular growth (Thomas et al., 1997), decreased time to conception (Espinoza et al., 1995; DeFries et al., 1998; Whitney et al., 2000), increased milk production (Canale et al., 1990; Sklan et al., 1991), and increased milk fat (Sklan et al., 1991; Drackley et al., 1998). Cows supplemented with fat had increased number and size of large follicles in dairy cows (Lucy et al., 1992), increased number of cows with luteal activity (Wehrman et al., 1991), prolonged lifespan of induced CL (Williams, 1989), increased serum progesterone concentrations after the first postpartum ovulation (Hightshoe et al., 1991), and increased pregnancy rates (Bellows et al., 1999). Although some researchers have reported

increased reproductive performance when vegetable oils or oilseeds have been fed to prepubertal heifers (Lammoglia et al., 2000; Whitney et al., 2000), first calf heifers (Bellows et al., 2001), or mature cows (DeFries et al., 1998), results have been equivocal in nearly every instance. Reproductive responses have been highly variable, and little is known about reasons for this variability. Some of it may be related to factors affecting nutrient flow out of the rumen (Howlett et al., 2003). The selective use of fat supplemented diets may be useful to increase body condition when prepartum energy deficiencies or suboptimal body condition scores exist at parturition; as best responses are reported in cows losing body condition during the postpartum period (Bottger et al., 2002). Lammoglia et al. (2000) reported a response in some breeds of heifers and related this response to back fat thickness. The thinnest group had a response to added dietary fat. The directional change in body condition score prior to rebreeding, however, may be of importance. Houghton et al. (1990) showed that cows in moderate body condition and increasing at the time of insemination had better conception rates than did cows in moderate body condition and losing condition at the time of insemination.

Practical Uses and Levels of Added Fats

In appropriate form, fat can be used to increase diet energy density and total energy intake, and replace a portion of the readily fermentable carbohydrate that may otherwise reduce fiber digestibility through negative associative effects. Consumption of large quantities of ruminally active fat (> 5% of total DMI) can markedly reduce dry matter intake in ruminants (Coppock and Wilks, 1991). Dose response studies indicate that the amount of added plant oil necessary to maximize positive ovarian effects is not less than 4% (Stanko et al., 1997), and most studies with a positive response have total

dietary fat ranges from 4 to 6%. Fats are highly digestible, and usually their effectiveness can be measured in fairly short durations of supplementation. High levels of fat can decrease calcium absorption by formation of calcium salts of fatty acids, and increase vitamin E requirements (NRC Beef, 1996). At some point (most studies show 6 to 8%), fat will reduce fiber digestion by: coating of fiber by fat, antimicrobial effects, impacting membranes and pH, a decreasing protozoa numbers, and/or decreasing availability of Ca needed for microbial function. The “coating” theory inhibits close contact of microbial cells with feed particles, which is necessary for cellulose digestion. Dry matter intake in dairy cows was not affected by 6 or 7% crude fat diets (Drackley et al., 1998, Komaragiri et al., 1998). Added fat is less detrimental to starch digestibility than it is to fiber digestibility; a dietary fat level of 10% can decrease digestion of structural carbohydrate by 50% (Ikwuegbu and Sutton, 1982; Jenkins and Palmquist, 1984). Increasing levels of fat leads to more propionic acid production and a decrease in acetate:propionate ratio. Changes in acetate:propionate ratio are mediated both through depression in fiber digestion and through direct metabolism of glycerol backbones of triglycerides to propionic acid (Church, 1976; Noble, 1978). Changes in ruminal volatile fatty acid production occur in response to increments in dietary fat, and the proportion of change is dependant on the degree of saturation of the fatty acids consumed and quantity fed (Jenkins, 1993). If ruminally protected sources of fat are used, increased levels can be fed; whole oilseeds would be one example of this and can be considered as partially bypass fats. Coppock and Wilks (1991) reported no differences in dry matter intakes when whole cottonseed was included at rates up to 25% of the diet, but other studies showed intake was suppressed at lower levels. Pancreatic lipase and colipase are needed

to further hydrolyze these “protected fats”. Higher digestibilities of oilseeds are observed in comparison with oil. This is probably a result of slower release of fatty acids as the oilseeds are chewed throughout the day, and this rate of release is within the biohydrogenation capabilities of healthy ruminal microbes (Coppock and Wilks, 1991). Site of digestion may be shifted as a result of oil inhibiting fiber digestion in the rumen. Fat supplementation, which decreases ruminal fermentation, might tend to shift carbohydrate fermentation to the large intestine (Demeyer, 1991). Saturated fatty acids are less disruptive than unsaturated; and saturated fatty acids are less ruminally digestible than unsaturated fatty acids (Coppock and Wilks, 1991). Crude protein of the diet can influence total tract digestibility of the fat; fatty acid digestibility went from 78 to 89% when crude protein increased from 16 to 20% (Andrews et al., 1990).

Calves Born to Fat Supplemented Dams

Focusing on strategies to improve the probability of conception and the production of a healthy calf that experiences minimal dystocia and survives beyond the first 24 h of birth should receive major attention (Bellows et al., 2002). Prepartum supplemental fat for beef cows warrants discussion because birth weight has been identified as the most important factor affecting calving difficulty (Bellows et al., 1971). Increased circulating steroid hormones associated with feeding fat to beef cows late in gestation may influence calf birth weight. Dietary fat-induced changes in circulating concentrations of steroid hormones at the end of pregnancy may influence calf birth weight (Lammoglia et al., 1996). Birth weight results of calves from dams that received supplemental fat during late gestation have been inconsistent. Two (Lammoglia et al., 1999b; Bellows et al., 2001) of the 14 prepartum dietary fat treatments increased calf

birth weight, two (Lammoglia et al., 1996; Lammoglia et al., 1999b) decreased calf birth weight, and calf birth weight was not affected by 10 of the prepartum fat supplementation programs. Calf genotype, sex, calving season, and source of supplemental fat may influence dietary fat effects on calf birth weight (Lammoglia et al., 1996).

Supplementing fat to beef cows during late gestation generally does not affect calf birth weight to a point of concern. Prevalence of calving difficulty is expected to be similar between fat supplemented cows and cows not supplemented with fat during late gestation (Bellows et al., 2001).

Research on calf tolerance to cold stress was a driving force behind initial studies involving added fat to gestating beef cows in Montana. Calves from dams that received supplemental fat during late gestation responded to cold stress by increasing rectal temperature, which was maintained for a longer period of time than calves from dams not fed supplemental fat (Lammoglia et al., 1999a,b; Bellows et al., 2001). Calf response to cold was related to increased availability of glucose for metabolism and heat production. Calves born to cows receiving high fat diets had higher levels of brown adipose tissue surrounding their internal organs. This provided calves with additional energy both through non-shivering thermogenesis as well as energy to maintain a shivering reflex longer, which in turn kept body temperature up. If calves were gestated in less harsh environments and exposed to milder environments after calving, prepartum fat supplementation did not affect apparent cold tolerance (Lammoglia et al., 1999b). Feeding fat to late gestational beef cows may improve the survivability of calves born in cold environments but does not appear to be beneficial in milder environments. In a

study by Geary et al. (2002), calf vigor was greater in calves born to fat supplemented cows, but this could also be attributed to a 3-d longer gestation length (284 vs. 281).

Weight gains of calves by fat supplemented dams have shown mixed results. Milk production is moderately to highly correlated with calf performance (Mallinckrodt et al., 1993), and calf weight gains showed a similar response to the dams' reproductive responses to fat supplementation. A response to supplemental fat appears to be dependant upon: body condition, age, nutrients in the basal diet, and type of fat supplement. Potential beneficial effects of feeding supplemental fat on calf performance may be more pronounced in dams in poor body condition. When adequate nutrients are available to the cow, the positive effects of supplemental fat on calf weight gain may be masked (Bellows, et al., 2001). Calves from dams in body condition scores ranging from 2.5 to 4.1 fed supplemental fat pre- and postpartum showed increased weight gains (Espinoza et al., 1995; DeFries et al., 1998). When cows were in moderate body condition throughout the study, and body weight gain of calves was not affected by feeding fat prepartum (Alexander et al., 2002; Bottger et al., 2002). In a review by Hess, results from 13 observations of cows fed fat and 9 observations in the control group posed numeric trends for weaning weight appeared to favor calves from cows that had been supplemented with fat, but combined results showed that weaning weights were not different. Responses in milk production to fat supplementation was increased in two (Coppock and Wilks, 1991; Tjardes et al., 1998) of the four studies (also Alexander et al., 2002; Bottger et al., 2002). Supplemental fat to beef cows does not have positive or negative affects on weight gain or weaning weight of calves.

Soybeans as a Feedstuff for Beef Cattle

The effect of the inclusion of soybeans depends on the extent to which they are included in the diet, but optimally can be utilized as efficiently as the protein in solvent soybean meal. Raw soybeans have a high raw energy concentration due to their low ash content and their high fat (16 to 20%) and protein (38 to 42%) content. These factors afford soybeans to be an attractive alternative feedstuff dependant upon market values. Soybeans have an advantage over some other energy sources fed to cattle due to the fiber contribution of the seed coat (hull). The concept of effective fiber is defined as the proportion of the total fiber that proves useful for stimulating mastication, rumination, insalivation, and ruminant motility (Blas and Rebollar, 2001). The effective fiber content for whole soybeans was established by Sniffen et al. (1992) as 100% of the NDF. To achieve a goal level of added dietary fat, soybeans are sometimes a cost effective alternative. This NDF value is higher than soybean meal or hulls due to the fact that whole soybeans require a greater degree of rumination. Therefore, the value should drop if the soybeans are offered rolled or ground. Soybeans are as safe as feeding low levels of any grain, and the trypsin inhibiting agent is not a concern in mature cattle because of the detoxifying ability of ruminal fermentation. Whole soybeans protect a portion of the unsaturated fatty acids from degradation in the rumen. The ruminal bacteria are very effective at hydrolyzing fatty acids from the triglyceride and then saturating the double bonds present in the fatty acid. Using whole beans protects a portion of the fatty acids from the ruminal bacteria so that these fatty acids can be absorbed. Tice et al. (1993) found an increase in post ruminal NDF digestion when corn silage diets were supplemented with whole soybeans. Brokaw et al. (2001) found no effects when free

soybean oil was supplemented. This suggests that some fiber in whole soybeans and soybean hulls escapes the rumen and is fermented in the hindgut. Other advantages of feeding whole soybeans are the obvious eliminated cost of processing, as well as less concerns with rancidity during storage. Raw soybeans contain urease, an enzyme which enhances the breakdown of urea to ammonia, and therefore raw soybeans should not be included in diets that contain urea as a supplemental protein source.

Data from six studies were reviewed by Monari et al. (1996), with the results indicating that the inclusion of raw soybeans, compared to a control diet using soybean meal in isoenergetic diets, has little effect on milk production and composition, even though it resulted in a slight drop in consumption, and consequently, a corresponding slight improvement in dietary efficiency. The effect of grinding raw soybeans was studied by Tice et al. (1993) and Dhiman et al. (1997). The results obtained indicated insignificant differences for all of the measured production variables. Monari et al. (1996) reported that soybeans constitute a valid alternative to feeds with a high starch concentration, and make it possible to formulate diets with high energy concentration that decreases the incidence of ruminal acidosis. The other contributing factor of feeding soybeans is the effect the dietary fat content has on reproduction, as some research shows increased first service conception rates and/or overall pregnancy rates.

Damaged Soybeans

Weather events that occur during seed-filling can kill plants before their normal maturation process takes place. High temperatures and dry soil is one event that can be detrimental to soybean plants. During drought conditions, water evaporation from the leaves is greater than the amount of water the roots can provide, which results in

denaturing of life-sustaining enzymes in the leaves, and the plants quickly die. Yield is reduced through reduced seed size, and the seeds do not mature normally and remain green from the chlorophyll pigment. Premature plant death stops natural degradation of chlorophyll and the seeds remain green. This retained chlorophyll can potentially cause oxidation of the oil, and thus greatly reduce shelf life (Maier and Parsons, 1996). The green color does not significantly change during storage. Studies have indicated that green soybeans store as well as high quality yellow beans if the moisture content is below 13%. The extent of the green color depends on the timing of the premature death. The later the death in seed filling, the less green seeds and less depth of green in each seed will be prevalent. Soybeans are sold according to grade and “soybeans of other color” are graded “standard” and receive substantial dockage. Protein accumulates in soybean seeds at the same rate as dry weight resulting in nearly constant protein concentration during seed-fill (Wiebold, 2001). Drought stressed soybeans (**DSSB**) should have close to normal protein percentages, but oil content might be lower because oil accumulation occurs mostly toward the end of seed-filling. It has been reported that a number of grain elevators have rejected green soybeans at a damage level above 7% during the harvest season; at this point, their value becomes a function of animal feed value, availability, and salvage value of the beans. Although the protein and fat content can be reduced by damaged plants, the damaged beans can serve as an excellent source of energy and protein in beef cattle rations and supplements.

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CHAPTER II

DROUGHT STRESSED SOYBEAN SUPPLEMENTATION FOR BEEF COWS

ABSTRACT:

Three experiments were conducted to determine the effects of supplementation with whole or rolled drought stressed soybeans (DSSB) on performance of beef cows. Experiment 1 involved the inclusion of DSSB as a winter supplement for gestating spring calving cows (n=91; initial BW = 557 kg; initial body condition score = 5.25). Cows grazed abundant dormant native tall-grass prairie pasture and were individually fed one of four treatment supplements for 88 d prior to onset of parturition. Treatments for Exp. 1 were: 1) 0.91 kg/d whole soybeans (WSB); 2) 0.91 kg/d rolled soybeans (RSB); 3) 1.26 kg/d of a traditional supplement of soybean meal and soybean hulls (PCON); and 4) no supplement (NCON). Experiment 2 was a 4 X 4 Latin square digestibility study (n=4; initial BW = 508 kg; initial body condition score = 5.5) with the same supplemental treatments as Exp. 1. Experiment 3 involved lactating fall calving cows (n=42; initial BW = 532 kg; initial body condition score = 4.75) and heifers (n=16; initial BW = 420 kg; initial body condition score = 4.5) that had ad libitum access to bermudagrass hay and were individually fed one of three treatments for 100 d through the winter. Treatments for Exp. 3 were: 1) 0.91 kg/d whole soybeans (WSB); 2) 0.91 kg/d rolled soybeans (RSB); and 4) no supplement (NCON). All three groups of supplemented cows in Exp. 1 maintained weight and body condition compared to severe weight and body condition

losses among NCON cows ($P < 0.05$). Similarly, cows nursing NCON cows weighed 18 kg less than calves from supplemented cows at weaning ($P < 0.05$). No differences among treatments were detected for pregnancy rates, although the soybean treatments were numerically greater (95 vs. 84%, respectively; $P = 0.34$). Dry matter intake was 31% greater for the supplemented treatments compared with NCON ($P < 0.05$) in Exp. 2. Supplementation also tended to increase total tract apparent dry matter digestibility ($P = 0.14$) and ADF digestibility ($P = 0.10$). In Exp. 3, cow and heifer weights were not affected by treatment during or after the supplementation period. There was a trend ($P = 0.10$) for supplemented cows and heifers to better maintain body condition during the supplementation period. Calves nursing supplemented cows tended to gain at a faster rate ($P = 0.08$) during the supplementation period compared with NCON calves. Pregnancy rates were not affected by treatments. This research indicates that DSSB can be an effective winter protein supplement for beef cows, and the added dietary fat did not impact cow performance or reproduction. The slight advantage to processing the soybeans did not significantly affect cow and calf performance or pregnancy rates.

Introduction

A moderate to high plane of nutrition prepartum reduces the postpartum anestrus interval (**PPI**) and increase pregnancy rates in beef cows (Selk et al., 1988). Low quality forages require protein and energy supplementation in order to insure an adequate plane of nutrition during late gestation and throughout lactation (Vanzant et al., 1991). Raw soybeans have a high energy concentration due to low ash concentration and their high fat (16 to 20%) and protein (38 to 42%) concentration. The trypsin inhibiting agent is not a concern in mature cattle because of the detoxifying ability of ruminal fermentation

(Fallon and Enig, 1995). Therefore, whole raw soybeans could be used to replace traditional supplemental protein and energy sources for beef cattle grazing low quality forages. Data from six studies were reviewed by Monari et al. (1996), who concluded that the inclusion of raw soybeans, compared with a control diet using soybean meal in isoenergetic diets for dairy cows had little effect on milk production and composition. In fact, in this review, Monari et al. (1996) concluded that dry matter intake is reduced in soybean fed cows, resulting in improved dietary efficiency.

Drought causes premature death in soybean plants which leads to reduced seed size. In addition, the natural degradation of chlorophyll is truncated, resulting in green seeds. Under these adverse conditions, protein accumulates in soybean seeds at the same rate as dry weight resulting in similar protein concentration of drought-stressed compared to non-stressed soybeans (Wiebold, 2001). Oil concentration of drought stressed soybeans (**DSSB**) is low because oil accumulation occurs mostly toward the end of seed-filling (Wiebold, 2001). Research evaluating the effectiveness of DSSB as a supplemental protein and energy source for range beef cows has not been published. The effect of grinding raw undamaged soybeans in dairy cow rations was studied by Tice et al. (1993) and Dhiman et al. (1997). The results obtained indicated insignificant differences for all of the measured response variables. However, research is not available to indicate whether DSSB should be processed in order to maximize supplemental nutrient utilization in beef cows consuming low quality forage. Therefore, the objectives of these experiments were to determine the effects of feeding DSSB as a protein and energy supplement to beef cows during winter grazing, and to determine if processing of DSSB was beneficial.

Materials and Methods

This research was conducted in accordance with an approved Oklahoma State University Institutional Animal Care and Use protocol. Three experiments involving beef cows at two stages of production were used to evaluate DSSB as a winter protein supplement. The DSSB used for these studies were grown near Stillwater, OK and were harvested in October 2000. The variety of soybeans purchased were 3502 ASGRO (Monsanto, 800 N. Lindbergh Blvd., St. Louis, MO 63167) and at time of purchase weighed 25.4 kg/bushel. Chemical composition is shown in Table 1. The soybeans graded #4 by the Official United States Standards for Grain; and the overall appearance was small, with about 50% of the beans being green and/or shriveled. One-half of the soybeans were processed through a 45.7-cm corrugated roller at the OSU feed mill. The roller was adjusted to a width capable of splitting the soybeans.

Experiment 1 – Late Gestation

This experiment was conducted during the winter of 2000-2001 at the Range Cow Research Center, near Stillwater, OK. Ninety-one spring calving multiparous gestating Angus and Angus x Hereford cows (BW = 557 ± 28 kg; BCS = $5.27 \pm .14$) received experimental supplements for an 88-d period (November 11, 2000 through February 9, 2001). Cows were managed as a contemporary group and had ad libitum access to abundant dormant native tall-grass prairie pasture and a mineral supplement (NaCl, 41.9%; Ca, 9.5%; P, 8.3%; Mg, 0.3%; Cu, 1039 ppm; Se, 12 ppm; and Zn, 3110 ppm; DM basis). Cows were rotated among four stockpiled pastures to ensure forage availability was never limiting. Native prairie grass hay (5% CP, 39% ADF, 72% NDF) harvested from an adjacent meadow was provided free choice for 20 d in December when

snow or ice covered the pasture. Supplement treatments (Table 1) included: 1) 0.91 kg/d of whole DSSB (WSB); 2) 0.91 kg/d of rolled DSSB (RSB); 3) 1.26 kg/d of high quality soybean meal and soybean hull supplement (PCON); and 4) no supplement (NCON). Experimental supplements were formulated to be isonitrogenous, isocaloric, and to meet CP requirements (NRC, 1996). Cows were stratified to supplement treatments so that age, initial BW and initial body condition scores (**BCS**) would be similar between groups. Cows were individually fed twice their daily supplement on an every-other-day basis in a covered stall barn. Individual cow BW and BCS were recorded after overnight withdrawal from feed and water at the initiation and end of the treatment period, at the onset of breeding, and at weaning. Body condition scores (scale 1 through 9; Wagner et al., 1988) were assigned by two independent technicians. The same two evaluators assigned BCS throughout the trial. Following the treatment period, cows were group fed 1.4 kg/d of a 40% CP range cube to meet protein requirements until there was adequate growth of pasture in the spring.

Estimates of milk production were obtained from the same 62 cows (11 WSB, 17 RSB, 19 PCON, 15 NCON) on April 11 (average calf age = 33d) and June 2 (average calf age = 85d) using the weigh-suckle-weigh technique. The earliest calving cows from each treatment were used for this portion of the study. In order to equalize milk volume in every cow, on each date there was a pre measurement overnight separation and nursing. The cows and calves were then separated for three consecutive 8-h periods. At each interval calves were weighed, allowed to nurse until satisfied, then reweighed to determine amount of milk produced per 8-h period. The sum of these three estimates was considered to be 24-h milk production.

The 91-d calving season lasted from February 9 to May 8 with an average calving date of March 9. Birth weight of each calf was recorded within the first 24h of birth. Plasma progesterone concentrations were measured prior to the start of the breeding season to determine the percentage of cows cycling. Blood samples were collected from each cow via tail venipuncture on May 2 and May 9. Concentrations of progesterone in plasma were quantified by radioimmunoassay (Vizcarra et al., 1997). Cows with ≥ 0.5 ng/mL progesterone in one or both plasma samples were considered to have ovarian luteal activity. Cows were exposed to four fertile Angus bulls for 66 d from May 10 to July 15, 2001. Pregnancy rate was determined by rectal palpation at weaning on September 18, 2001.

Experiment 2 – Intake and Digestibility

This experiment was conducted at the Nutrition and Physiology Research Center, Stillwater, OK, in accordance with an approved Oklahoma State University Animal Care and Use Committee protocol. Four Angus X Hereford gestating beef cows (age = 4; BW = 508 ± 11 kg) were used in a Latin square design to determine the effects of three supplements on diet intake and total tract apparent digestibility. Supplement treatments (Table 6) included: 1) 0.91 kg/d of whole DSSB (WSB); 2) 0.91 kg/d of rolled DSSB (RSB); 3) 1.26 kg/d of high quality soybean meal and soybean hull supplement (PCON); and 4) no supplement (NCON). Experimental supplements were formulated to be isonitrogenous, isocaloric, and to exceed CP requirements (NRC, 1996). Each period consisted of 14-d diet adaptation followed by 7-d sample collection. During the experiment, cows were housed in individual indoor 3- x 4-m pens. Cows had ad libitum access to water and prairie hay (5% CP, 39% ADF, and 72% NDF). This was

accomplished by offering 2.3 kg more hay than the previous day's hay intake. Prairie hay was processed through a hammer mill before feeding. Daily hay intake was measured directly and fecal output was estimated using acid detergent insoluble ash as an internal marker. Hay, supplement, orts, and feces were composited by cow for each period. A sub-sample of each composite was dried at 100⁰ C for 24 h to determine dry matter. Composite samples were dried at 50⁰ C for 48 h before grinding. Samples were ground (No. 4 Wiley Mill, Thomas Scientific, Swedeboro, NJ) to pass through a 2-mm screen before analyses. All samples were analyzed for fat, crude protein (**CP**), acid detergent fiber (**ADF**), neutral detergent fiber (**NDF**), and acid detergent insoluble ash (**ADIA**). An ether extraction procedure was used to estimate lipid content (Servi-Tech Laboratories, Dodge City, KS). Crude protein was determined using a Leco NS-2000 Nitrogen Analyzer (Leco Corporation, St. Joseph, MI). Acid detergent fiber and NDF were determined using an ANKOM Fiber Analyzer (ANKOM Technology, 2005a,b). Acid detergent insoluble ash was determined as the residue following complete combustion of the ADF residue (Van Soest et al., 1991).

Experiment 3 – Lactation

This trial was conducted with fall calving beef cows and heifers during the winter of 2000-2001 at the Eastern Oklahoma Research Station, near Haskell, OK. Forty-two fall calving lactating multiparous cows (BW = 532 ± 32 kg) and 16 fall calving lactating primiparous cows (BW = 420 ± 15 kg) were used for the 100-d supplementation period (December 18 through March 28, 2001). Cows were managed as a contemporary group, and offered ad libitum access to bermudagrass (*Cynodon dactylon*) hay (8.7% CP, 79% NDF, and 46% ADF). Cows were allotted by weight and age to one of three supplement

treatments: 1) 0.91 kg/d of whole DSSB (WSB); 2) 0.91 kg/d of rolled DSSB (RSB); or 3) no supplement (NCON). Soybeans were fed at this rate to deliver 0.35 and 0.89 kg/d of CP and TDN, respectively. Chemical composition of soybeans is presented in Table 1. The WSB and RSB supplemented cows were fed 2.1 kg of beans on Monday, Wednesday, and Friday each week. Portable supplementation trailers (Commanche Manufacturing, Joplin, MO) were used to deliver the supplements on an individual basis. Cow BW and BCS, along with calf weights were collected after overnight withdrawal from feed and water on days 0, 37, and 100 of the supplementation period and at weaning. Body condition (scale 1 to 9; Wagner et al., 1988) was scored independently by the same two technicians throughout the trial. Following the supplementation period, cows were managed as a contemporary group and grazed bermudagrass pastures. Calves were weaned on June 28, 2001, and pregnancy of cows was determined by rectal palpation at this time.

Statistical Analysis

Cow was considered to be the experimental unit because treatments were fed individually. Data were analyzed using MIXED MODEL procedures of SAS (SAS Inst. Inc., Cary, NC) and the Satterthwaite approximation for degrees of freedom. When the P-value for the F-statistic was ≤ 0.05 , least squares means were separated using the LSD procedure of SAS. Least squares means are reported in all tables with the exception of means for luteal activity and pregnancy rates.

In Exp. 1, the model for cow performance included treatment as a fixed effect and cow age as a covariate. The model for milk production included treatment and calf sex as fixed effects; cow and calf age were included as covariates. Cow age was used as a

covariate for all dependant calf performance variables and calf age was included as a covariate in the weaning weight model. A Chi-square test was used to analyze differences in pregnancy rates and percent cows with ovarian luteal activity at onset of breeding.

In Exp. 2, intake and digestibility measurements were analyzed with a model appropriate for a Latin square using MIXED MODEL procedures of SAS and the Satterthwaite approximation for degrees of freedom. Period and treatment were included as fixed effects and cow included as a random effect.

In Exp. 3, the model for cow performance included treatment as a fixed effect and cow age class as a covariate. Cow age class was used as a covariate for all dependant calf performance variables. A Chi-square test was used to analyze differences in pregnancy rates.

Results and Discussion

Experiment 1 – Late Gestation

Cow weight and BCS change. Cow weight and BCS changes are summarized in Table 2. Differences in BW changes between all four treatments were observed ($P < 0.05$) during the supplementation period, as cows receiving the traditional supplement (PCON) best maintained weight. The RSB treatment ranked second, followed by the WSB group, and the NCON treatment weighed 81 kg less than PCON treatment by the end of the supplemental treatment period. From the end of the treatment period to the start of the breeding season all cows lost weight due to parturition. Weight losses during parturition were greatest ($P < 0.05$) for the RSB and PCON treatments. Cows from the supplemented treatments lost an average of 50 kg during calving, in agreement with

Marston et al. (1995) who reported approximately 60 kg of precalving weight was lost during calving. In contrast to the treatment period, the NCON group lost the least amount of weight from the end of the treatment period to the start of breeding ($P < 0.05$) and gained the most weight throughout the summer ($P < 0.05$). There was no difference ($P = 0.68$) in overall cow weight change throughout the experiment (-25.3 kg). Body condition scores and body condition changes are summarized in Table 2. The NCON treatment lost ($P < 0.05$) 1.2 more condition score units than the average of the three supplemented treatments. Similar to weight changes, the NCON group gained more condition ($P < 0.05$) during subsequent periods, and at weaning, there was no difference among treatments in BCS ($P = 0.93$).

Cows grazing dormant tall-grass native range in the Southern Great Plains require protein supplementation in order to maintain BW and BCS prior to calving (Marston et al., 1995). Fiber digestibility is increased when beef cattle consuming low-quality forages are supplemented with protein (Del Curto et al., 1990; Koster et al., 1996). Forage intake increases in response to providing increased quantities of protein supplements to ruminants fed protein deficient forages (Guthrie and Wagner, 1988; Stokes et al., 1988).

The differences in weight change during the supplementation period could be attributed to a variety of factors. The protein in the soybeans may not have been as digestible in comparison to PCON. Other research has indicated added dietary fat at levels greater than 5% of total dietary intake can cause reduced forage intake and fiber digestion (Coppock and Wilks, 1991; Jenkins, 1993). The dietary fat concentration of the

two soybean treatments were well below this level; therefore, this difference in weight change were not likely not caused by excessive supplemental fat.

Although a difference in BCS change was not detected, substantially lower weight loss (18.3 kg, $P < 0.05$) of the RSB supplemented cows vs. WSB supplemented cows suggests that processing of DSSB may enhance nutrient availability.

Milk Production. Early and mid-lactation milk production is summarized in Table 3. Supplemented cows had 2.6 kg greater ($P < 0.01$) milk yield compared with unsupplemented cows. These findings relate to a study by Wiley et al. (1991) where a tendency ($P = 0.11$) for greater milk production of primiparous cows on different levels of prepartum nutrition was observed. The differences in the mid-lactation measurement of milk production are difficult to explain, as they did not follow any of the other response variables. Other researchers have reported no effect of prepartum lipid supplementation on subsequent milk production (Alexander et al., 2002).

Calf Performance. Calf birth weights followed the same pattern as cow weight changes and are summarized in Table 4. Calves born to the supplemented cows were 3.9 kg heavier ($P < 0.05$) compared to calves born to NCON cows. Dystocia was not detected in any of the four treatments. Previous research has shown that undernourished gestating cows or heifers have decreased calf birth weights (Bagley and Evans, 2004). In accordance with increased early lactation milk yield, average weaning weight for the three supplemented treatments was 19 kg greater ($P = 0.05$) compared with NCON. However, neither supplement source nor processing of DSSB influenced calf weights. Hess et al. (2002) concluded that the majority of studies reported no difference in calf birth weight or weaning weight due to prepartum lipid supplementation. These findings

would coincide with our results as there were no differences in birth or weaning weights among the three supplemented groups.

Cow Reproductive Performance. Table 5 summarizes the reproductive performance of cows in Exp. 1. In terms of percentage of cows with luteal activity at the onset of the breeding season, the RSB and PCON treatments were similar with about 40% units greater in number of cows cycling compared with NCON and WSB. Post partum interval for this study was defined as the days from calving to conception. Day of conception was calculated by subtracting 281 days from each cows 2002 calving date. Average calving date was 10 days later for the WSB treatment compared with the average of the other three treatments; therefore, the WSB treatment was an average of 45 days past calving at the onset of breeding in comparison to an average of 55 days for the other three treatments. The decreased number of NCON cows with luteal activity at the onset of the breeding season might be linked to their prepartum plane of nutrition; and calving date explains why the WSB supplemented cows were lower. Selk et al. (1988) found that restriction of nutrient intake during the last trimester of pregnancy reduced reproductive efficiency. Although not statistically different, the WSB group compensated with a numerically shorter post partum interval to conception when compared to the other three treatments. Laflamme and Conner (1992) indicated that pregnancy rate, return to estrus, and calving interval were not affected if cows were allowed to achieve or exceed a threshold BCS and (or) consume a sufficient amount of nutrients. The average BCS at calving for cows among three supplemented treatments was 4.8 in comparison with 3.6 for the NCON treatment. Other researchers have found that feeding supplemental lipid prepartum did not influence the percentage of cows

cycling at the beginning of the breeding season (Bellows et al., 2001; Alexander et al., 2002). Pregnancy rates were not influenced by treatments. Both soybean treatments were 11% units higher numerically ($P = 0.34$) when compared to the PCON group. A larger number of observations may have detected a difference in pregnancy rates. Alexander et al. (2002) reported no difference in pregnancy rates for cows fed prepartum lipid treatments compared with control cows, whereas Bellows et al. (2001) reported increased pregnancy rates for cows fed whole soybeans prepartum compared with traditional supplements.

Experiment 2 – Intake and Digestibility

Intake and digestibility of dietary components are shown in Table 7. Dry matter intake, expressed as a percent of body weight, was greater ($P < 0.05$) for WSB, RSB, and PCON, compared with NCON. This is likely due to the increased protein content of the supplemented diets as discussed previously. Numerous experiments have shown dramatic increases in intake when cattle fed nitrogen deficient forage are supplemented with protein (Guthrie and Wagner, 1988; Stokes et al., 1988; Scott and Hibberd, 1990). Supplementation tended to increase apparent dry matter digestibility ($P = 0.14$) and ADF digestibility ($P = 0.10$).

In this experiment, dietary fat concentrations were: 2.1, 2.5, 2.4, and 2.1% for the NCON, WSB, RSB, and PCON treatments, respectively. These low dietary fat concentrations most likely explain why no differences in apparent dry matter digestibility or fiber digestibility were observed among treatments. Coppock and Wilks (1991) reported quantities of ruminally active fat greater than 5% can markedly reduce dry matter intake and digestibility in ruminants. Apparent fat and CP digestibility was higher

($P < 0.05$) for WSB, RSB, and PCON, compared with NCON. No differences in apparent fat and CP digestibility were found between WSB and RSB treatments.

Experiment 3 – Early Lactation

Weights and BCS changes and pregnancy data for the fall calving study are summarized in Table 8. The effects of lactation treatment on calf performance are in Table 9. Weight changes were similar for cows on all treatments during and after the supplementation period. There was a trend ($P = 0.10$) for the cows fed supplement to maintain greater body condition during the supplementation period compared with the non-supplemented group. A tendency ($P = 0.09$) was also detected in body condition change for the WSB treatment after supplementation, as they gained less than the RSB and NCON treatments. Calves nursing supplemented cows tended ($P = 0.08$) to gain at a faster rate during the supplementation period compared with calves nursing NCON cows. Moderately improved calf performance during the supplementation period is indicative of increased milk production or increased milk nutrient concentration in supplemented cows. However, weaning weights of calves were not influenced by treatments. Marston et al. (1995) reported weaning weights of calves from cows fed adequate protein or energy supplements were similar, but offspring of higher protein supplemented cows tended to weigh less at weaning. Pregnancy rate was not affected ($P = 0.88$) by treatment, ranging between 85 and 90%. These tendencies for improved cow and calf performance during supplementation indicate that supplements were moderately effective in improving nutritional status during the treatment period. However, processing of DSSB did not further improve this response.

Implications

Supplementation of DSSB results in similar overall cow and calf performance compared to more traditional protein and energy supplementation sources. There appears to be a marginal advantage to rolling the soybeans, although this slight advantage did not significantly affect weaning weight of calves or pregnancy rate of cows. When economically feasible situations arise, drought stressed soybeans can be used as an effective winter supplement for beef cows.

Table 1. Experiment 1 and 3 - Supplement composition

Item	Treatment ^a		
	WSB	RSB	PCON
Soybeans, % DM	100	100	-
Soybean meal, % DM	-	-	45.4
Soybean hulls, % DM	-	-	54.2
Dicalcium phosphate, % DM	-	-	0.4
Nutrient Composition			
Dry matter, %	93	93	91
Crude protein, %	38	38	28
Fat, %	16	16	2.58
Feeding rate, kg/d	0.91	0.91	1.26
CP supplied, kg/d	0.35	0.35	0.35
TDN supplied, kg/d	0.86	0.86	1.03
Fat supplied, kg/d	0.15	0.15	0.03

^aWSB = whole drought stressed soybeans, RSB = rolled drought stressed soybeans,

PCON = positive control.

Table 2. Effect of late-gestation supplement on cow weight and body condition score change (Exp. 1)

Item	Treatment ^a				SEM ^b	P-Value ^c
	WSB	RSB	PCON	NCON		
Cows, no.	21	22	25	23		
Initial wt (11/13/00), kg ^d	569	557	555	552	13.6	0.82
Wt change (11/13/00 to 2/9/01), kg ^e	-25.7 ^w	-7.4 ^x	11.3 ^y	-66.5 ^z	4.6	<0.01
Wt change (2/9 to 5/9/01), kg ^f	-33.0 ^w	-54.2 ^x	-62.5 ^x	-12.7 ^y	4.4	<0.01
Wt change (5/9 to 9/18/01), kg ^g	32.0 ^w	31.8 ^w	29.8 ^w	55.9 ^x	3.9	<0.01
Wt change (11/13/00 to 9/18/01), kg ^h	-26.7	-29.8	-21.3	-23.3	5.5	0.68
Final wt (9/18/01), kg	542	526	534	528	11.1	0.74
Initial BCS (11/13/00)	5.25	5.26	5.35	5.20	0.136	0.86
BCS change (11/13/00 to 2/9/01)	-0.53 ^w	-0.48 ^w	-0.33 ^w	-1.60 ^x	0.096	<0.01
BCS change (2/9 to 5/9/01)	0.05 ^w	-0.18 ^w	-0.20 ^w	0.63 ^x	0.098	<0.01
BCS change (5/9 to 9/18/01)	0.31 ^w	0.40 ^w	0.31 ^w	0.78 ^x	0.093	<0.01
BCS change (11/13/00 to 9/18/01)	-0.16	-0.26	-0.22	-0.20	0.110	0.93
Final BCS (9/18/01)	5.09	4.99	5.14	5.01	0.142	0.86

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans (WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); 3) 1.26 kg/d of traditional supplement (PCON); and 4) no supplement (NCON).

^bMost conservative SEM.

^cProbability of a treatment effect

^dBeginning of the treatment period.

^eBeginning to end of the treatment period.

^fEnd of the treatment period to the beginning of the breeding season.

^gBeginning of the breeding season to weaning.

^hBeginning of the treatment period to weaning.

^{wxyz}Means within a row without a common superscript letter differ ($P \leq 0.05$).

Table 3. Effect of late-gestation supplement on early- and mid-lactation milk production, kg/d (Exp. 1)

Item	Treatment ^a				SEM ^b	P-Value ^c
	WSB	RSB	PCON	NCON		
Cows, no.	11	17	19	15		
Early-lactation ^d	9.42 ^{xy}	10.50 ^x	9.52 ^x	7.18 ^y	0.97	<0.01
Mid-lactation ^e	10.52 ^x	8.16 ^y	7.45 ^y	8.88 ^{xy}	0.94	0.05

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans (WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); 3) 1.26 kg/d of traditional supplement (PCON); and 4) no supplement (NCON).

^bMost conservative SEM.

^cProbability of a treatment effect.

^dMeasured on 4/11/01, avg calf age = 33 d, range = 17 to 63 d.

^eMeasured on 6/2/01, avg calf age = 85 d, range = 69 to 115 d.

^{xy}Means within a row without a common superscript letter differ ($P \leq 0.05$).

Table 4. Effect of late-gestation supplement on calf birth weight and weaning weight
(Exp. 1)

Item	Treatment ^a				SEM ^b	P-Value ^c
	WSB	RSB	PCON	NCON		
Cows, no.	21	22	25	23		
Birth wt, kg	38.3 ^x	37.7 ^x	39.7 ^x	34.5 ^y	0.93	<0.01
Weaning wt, kg (avg age = 185 d)	220.3 ^x	225.0 ^x	218.7 ^x	203.7 ^y	6.1	0.05

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans

(WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); 3) 1.26 kg/d of traditional supplement (PCON); and 4) no supplement (NCON).

^bMost conservative SEM.

^cProbability of a treatment effect.

^{xy}Means within a row without a common superscript letter differ ($P \leq 0.05$).

Table 5. Effect of late-gestation supplement on reproductive performance (Exp. 1)

Item	Treatment ^a				SEM ^b	P-Value ^c
	WSB	RSB	PCON	NCON		
Cows, no.	21	22	25	23		
Days from calving to breeding season	45	59	53	54	4.13	0.10
Post partum interval, days ^d	65	76	71	87	6.47	0.11
Cows cycling, % ^e	23.8 ^x	63.6 ^y	60.0 ^y	21.7 ^x		<0.01
Pregnancy rate at weaning, %	95.2	95.5	84.0	82.6		0.34

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans (WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); 3) 1.26 kg/d of traditional supplement (PCON); and 4) no supplement (NCON).

^bMost conservative SEM.

^cProbability of a treatment effect.

^dDays from calving to conception.

^eCows cycling at the start of the breeding season.

^{xy}Means within a row without a common superscript differ ($P \leq 0.05$).

Table 6. Experiment 2 - Supplement composition

Item	Treatment ^a		
	WSB	RSB	PCON
Soybeans, % DM	100	100	-
Soybean meal	-	-	45.4
Soybean hulls	-	-	54.2
Dicalcium Phosphate	-	-	0.4
Nutrient Composition			
CP, %	38	38	28
Ash, %	5.4	5.12	6.61
Fat, %	7.55	7.88	2.58
NDF, %	24.75	21.69	40.12
ADF, %	14.39	12.28	28.81
Feeding rate, kg/d	0.91	0.91	1.26
CP supplied, kg/d	0.35	0.35	0.35
TDN supplied, kg/d	0.86	0.86	1.03
Fat supplied, kg/d	0.07	0.07	0.03

^aWSB = whole drought stressed soybeans, RSB = rolled drought stressed soybeans,

PCON = positive control.

Table 7. Effect of supplement on daily intake and apparent digestibility of dietary components (Exp. 2)

Item	Treatment ^a				SEM ^b	P-Value ^c
	WSB	RSB	PCON	NCON		
Intake						
Hay, kg/d	10.9 ^x	10.4 ^x	10.7 ^x	8.0 ^y	0.37	<0.01
Hay, % body weight	2.1 ^x	2.1 ^x	2.1 ^x	1.6 ^y	0.05	<0.01
Dry matter (hay and supp.), kg/d	11.8 ^x	11.3 ^x	11.8 ^x	7.3 ^y	0.41	<0.01
Dry matter, % body weight	2.3 ^x	2.2 ^x	2.3 ^x	1.6 ^y	0.07	<0.01
Fecal Output DM, kg/d	6.22 ^x	5.77 ^x	5.81 ^x	4.13 ^y	0.32	<0.01
Digestibility						
Apparent Dry Matter, %	47.5	49.8	51.1	43.9	1.97	0.14
Apparent Fat, % DM	36.7 ^x	39.3 ^x	34.6 ^x	24.8 ^y	2.93	<0.01
Apparent CP, % DM	42.5 ^x	42.4 ^x	43.6 ^x	22.0 ^y	3.22	<0.01
NDF, % DM	51.1	54.0	54.7	49.1	2.00	0.26
ADF, % DM	51.9	54.2	54.6	48.2	1.75	0.10
Total digestible dry matter intake, kg/d	5.6 ^x	5.6 ^x	6.0 ^x	3.2 ^y	0.37	<0.01

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans (WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); 3) 1.26 kg/d of traditional supplement (PCON); and 4) no supplement (NCON).

^cProbability of a treatment effect.

^{xy}Means within a row without a common superscript letter differ ($P \leq 0.05$).

Table 8. Effect of lactation supplement on cow weight change and body condition score change (Exp. 3)

Item	Treatment ^a			SEM ^b	P-Value ^c
	WSB	RSB	NCON		
Cows, no.	19	20	19		
Initial wt (12/18/00), kg ^d	501	493	483	19.5	0.81
Wt change (12/18/00 to 3/28/01), kg ^e	-29	-30	-32	3.0	0.81
Wt change (3/28 to 6/28/01), kg ^f	-3	9	9	5.5	0.22
Wt change (12/18/00 to 6/28/01), kg ^g	-32	-21	-23	14.0	0.42
Final wt (6/28/01), kg	469	472	460	16.4	0.87
Initial BCS (12/18/00)	4.76	4.78	4.74	0.10	0.96
BCS change (12/18/00 to 3/28/01)	-0.14	-0.19	-0.44	0.10	0.10
BCS change (3/28 to 6/28/01)	0.05	0.44	0.43	0.14	0.09
BCS change (12/18/00 to 6/28/01)	-0.09	0.24	-0.01	0.13	0.17
Final BCS (6/28/01)	4.67	5.02	4.73	0.20	0.18
Pregnancy rate at weaning, %	90	85	90		0.88

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans (WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); and 3) no supplement (NCON).

^bMost conservative SEM.

^cProbability of a treatment effect.

^dBeginning of the treatment period.

^eBeginning to end of the treatment period.

^fEnd of the treatment period to weaning.

^gBeginning of the treatment period to weaning.

Table 9. Effect of lactation supplement on calf performance (Exp. 3).

Item	Treatment ^a			SEM ^b	P-Value ^c
	WSB	RSB	NCON		
Cows, no.	19	20	19		
Initial wt (12/18/00), kg ^d	87	87	94	6.7	0.64
Wt change (12/18/00 to 3/28/01), kg ^e	63	64	55	3.0	0.08
Wt change (3/28 to 6/28/01), kg ^f	81	74	80	4.8	0.52
Wt change (12/18/00 to 6/28/01), kg ^g	144	138	135	4.9	0.40
Weaning wt (6/28/01), kg	231	224	230	8.5	0.84

^aTreatments (dry matter basis) were: 1) 0.91 kg/d of whole drought stressed soybeans (WSB); 2) 0.91 kg/d of rolled drought stressed soybeans (RSB); and 3) no supplement (NCON).

^bMost conservative SEM.

^cProbability of a treatment effect.

^dBeginning of the treatment period.

^eBeginning to end of the treatment period.

^fEnd of the treatment period to weaning.

^gBeginning of the treatment period to weaning.

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VITA

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Master of Science

Thesis: DROUGHT STRESSED SOYBEAN SUPPLEMENTATION FOR BEEF
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Scope and Method of Study: Three experiments were conducted to determine the effects of supplementation with whole or rolled drought stressed soybeans (**DSSB**) on performance of beef cows. Exp. 1 involved the inclusion of DSSB as a winter supplement for gestating spring calving cows (n=91; initial BW = 557 kg; initial body condition score = 5.25). Cows grazed abundant dormant native tall-grass prairie pasture and were individually fed one of four treatment supplements for 88 d prior to onset of parturition. Treatments for Exp. 1 were: 1) 0.91 kg/d whole soybeans (WSB); 2) 0.91 kg/d rolled soybeans (RSB); 3) 1.26 kg/d of a traditional supplement of soybean meal and soybean hulls (PCON); and 4) no supplement (NCON). Experiment 2 was a 4 X 4 Latin square digestibility and intake study (n=4; initial BW = 508 kg; initial body condition score = 5.5) with the same supplemental treatments as Exp. 1. Experiment 3 involved lactating fall calving cows (n=42; initial BW = 532 kg; initial body condition score = 4.75) and heifers (n=16; initial BW = 420 kg; initial body condition score = 4.5) that had ad libitum access to bermudagrass hay and were individually fed one of three treatments for 100 d through the winter. Treatments for Exp. 3 were: 1) 0.91 kg/d whole soybeans (WSB); 2) 0.91 kg/d rolled soybeans (RSB); and 4) no supplement (NCON).

Findings and Conclusions: Experiment 1 demonstrated the importance of winter protein supplementation to gestating beef cows grazing dormant native range in terms of cow performance and calf weaning weights. No difference was detected in pregnancy rates. Drought stressed soybeans are an effective winter supplement source for beef cows, and processing these beans to the rolled form is not essential. Dry matter intake was 31% greater for the supplemented treatments compared with NCON ($P < 0.05$) in Exp. 2. Supplementation also tended to increase total tract apparent dry matter digestibility ($P = 0.14$) and ADF digestibility ($P = 0.10$). In Exp. 3, there was a trend ($P = 0.10$) for supplemented cows and heifers to better maintain body condition during the supplementation period. Weaning weights and pregnancy rates were not affected by treatments. This research indicates that DSSB can be an effective winter protein supplement for beef cows. The slight advantage to processing the soybeans did not significantly affect cow and calf performance or pregnancy rates.

ADVISER'S APPROVAL: Dr. David Lalman