H. Rubio Arias et al., Int. J. Sus. Dev. Plann. Vol. 1, No. 2 (2006) 226–232

SUSTAINABLE COTTON PRODUCTION BY USING CATTLE TO GRAZE HARVEST RESIDUES IN MEXICO

H. RUBIO ARIAS[1], M.A. FLORES[1], M.K. WOOD[2] & M. GUTIERREZ[3]
[1]INIFAP, Campo Experimental la Campana-Madera, Chihuahua, Chihuahua, Mexico.
[2]Water Resources Research Institute, New Mexico State University, USA.
[3]Southwest Missouri State University, USA.

ABSTRACT

Twenty crossbred beef steers and twenty crossbred beef heifers were randomly allotted to two treatments to evaluate the effect of supplementation on animal performance in animals grazing cotton plant residues: (1) 10 steers and 10 heifers were allowed to graze *ad libitum* in an 8 ha cotton field after harvest, and (2) 10 steers and 10 heifers grazed in a similar field but received 1 kg day^{-1} of supplement. Water intake and mineral consumption were measured daily. Cotton plant residues were obtained from an adjacent 10 ha field by collecting 12 representative samples using a 1 m^2 frame, and separating leaves and cottonseeds for lab analysis. Dry matter (DM), crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), cellulose, lignin, silica, calcium, phosphorus and nitrogen ADF were determined. Supplementation did not affect the total weight gain of the steers or the heifers during the 30-day grazing period. The unsupplemented steers gained 0.500 kg day^{-1}, while the supplemented steers gained 0.466 kg day^{-1}. The supplemented and unsupplemented heifers gained 0.266 kg and 0.233 kg day^{-1}, respectively. Water intake did not differ between treatments, but mineral consumption was significantly greater for the unsupplemented calves. The total cotton residues in the soil accounted for about 2,100 kg ha^{-1} of DM. The economic analysis indicated an increased profitability when using steer calves without supplementation.

Keywords: grazing, cotton residues, sustainability, economic impact, Chihuahua, Mexico.

1 INTRODUCTION

Mexico's farmers plant approximately 230,000 ha of cotton (*Gossypium hirsutum* L.) each year [1]. This plant specie is an important cash crop for the Mexican agrarian sector. Like cotton farmers worldwide, Mexico's producers look for new technologies to increase their net profitability now and in the future. The final goal is to manage all the inputs in an optimal fashion while maximizing the total output of the cotton production systems. It is hoped that the cotton plant residues can be useful instead of being a burden. After harvesting the cotton, considerable amounts of plant residues remain, representing potential feedstuffs for ruminants [2]. From a worldwide perspective, stalk destruction is a common practice; while in Mexico, some producers have begun cattle-raising activities with cotton residues. Moreover, several million tons of cotton by-products are produced in the cotton industry [3]. Little attention has been given to grazing on plant residues in the field, while most research has focused on cotton gin trash [4], although both sources might produce acceptable gains in steers and heifers. Grazing in cotton fields might result in a reduction of weevil infestations [5, 6], which is a needful process in a cotton sustainable system.

During the last decade, Mexican farmers have increasingly mechanically harvested cotton instead of handpicking. This change has resulted in more plant residues being left in the field. Ruminants could utilize these residues. Although this roughage is considered low in quality [2] because of the large amount of lignins that are low in digestibility [7], its use may be improved through manipulating rumen function with supplementation.

To date, very limited information is available on the weight gain of recently weaned male and female calves when consuming cotton residues. Therefore, the objective of this trial is to determine the effect of grazing cotton residues on the weight gain of steer and heifer calves. Furthermore, we wish to determine the advantage of a commercial supplement when grazing cotton residues. The criterion

ISSN: 1743-7601 (paper format), ISSN: 1743-761X (online), http://journals.witpress.com
DOI: 10.2495/SDP-V1-N2-226-232

for evaluating treatment effects was the average daily gain (ADG) during a 30-day period following a 10-day adjustment period. Water intake and mineral intake were also measured. An economic analysis was conducted to estimate profitability of each treatment.

2 MATERIALS AND METHODS

This trial was conducted at an experimental station of Juarez Valley, located in the northern part of the state of Chihuahua, Mexico (Fig. 1). The experimental station was located in the city of Praxedis Guerrero, near the state of Texas in the USA. Twenty recently weaned beef steers with a mean live weight of 188.50 kg (SD = 17.92) and 20 heifers, also recently weaned with 172.00 kg live weight (SD = 11.85), were used. All the animals (*Bos taurus* L.) were between 210 and 240 days of age. The calves were raised on the same ranch with a short grass community dominated by blue grama (*Bouteloua gracilis* [Willd ex H.B.K.] lag. Ex. Griffiths). The dams were genetically similar (Hereford) and were managed in a similar manner. The sires used on this ranch for breeding purposes were Salers, Limousin and Charolais; therefore, the calves used in this study were Hereford-Salers, Hereford-Limousin and Hereford-Charolais crosses. Ten steers and 10 heifers were randomly

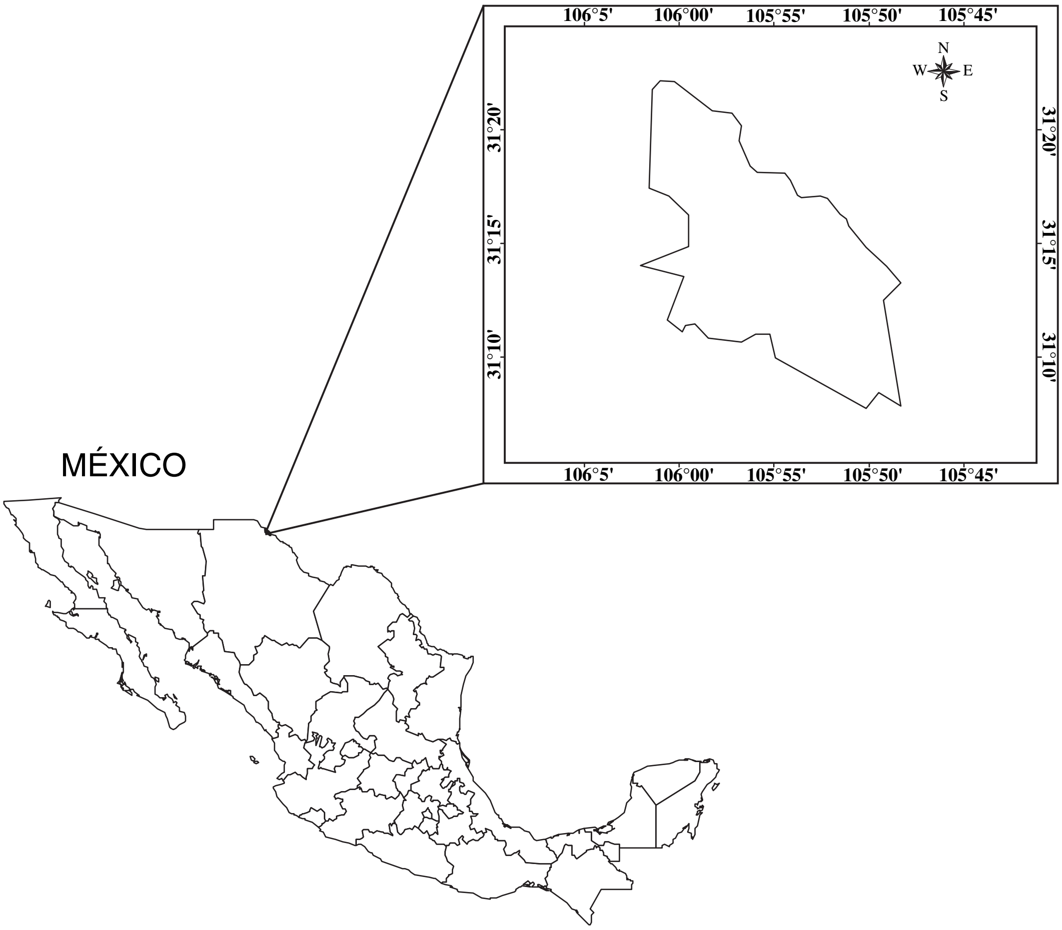

Figure 1: Study area in the Municipality of Praxedis Guerrero, Chihuahua, México.

assigned to each of the two treatments. Treatment one (control) was consumption of only cotton plant residues in an 8 ha field. Treatment two consisted of cotton plant residues in a similar 8 ha field, but with 1 kg day^{-1} of supplement (Registered Trademark of Ranch-Way, Inc., Fort Collins, CO, USA). The supplement contained 16% CP (having no more than 1.0% equivalent protein from non-protein nitrogen), 2% crude fat and a maximum of 15% crude fiber. The supplement was offered at 12:00 hours each day.

All the animals were identified with a numbered ear tag and dewormed with Ivomex (Merck & Co., Inc., Whitehouse Station, NJ, USA) through the application of 1 ml 50 kg^{-1} of body weight. In addition, all animals received an injection of Vitamin ADE (Durvet, Inc., Blue Springs, MO, USA) using 1 ml 50 kg^{-1} of body weight. Cattle were weighed at the beginning of the study (November 24) after a 10-day adjustment period (from November 13 to November 23) and every 15 days thereafter. Because cotton fields must be fallow and vacated before January due to sanitation laws, the experiment was terminated and the final weights were taken on December 23.

Water was offered in five containers placed in each pasture. Each container was weighed daily at 12:00 hours to evaluate the daily water intake. A salt block (25 kg total weight) fortified with seven essential trace elements (United Salt Corporation, Houston, TX, USA) was placed near each set of water containers and was weighed daily at 12:00 hours to estimate the consumption. Guaranteed analysis of the block was: salt (NaCl) 93–97%, chlorine 25 ppm, copper 150 ppm, iodine 90 ppm, iron 1,500 ppm, manganese 3,000 ppm, selenium 20 ppm, and zinc 2,500 ppm.

Samples of cotton plant residues were obtained on November 5 to estimate the total amount of DM in a field. A 1 m^2 frame was used to collect 12 samples of cotton residues for nutritional analysis. Leaves and hulls were analyzed separately. Analysis included: crude protein that was estimated by the procedure outlined by the Association of Official Agricultural Chemists [8]; NDF and ADF that were determined according to the methods of Guering and Van Soest [9]; cellulose, lignin and silica that were determined by the method described by Guering and Van Soest [9] using the fibertec system; calcium was obtained by the titrimetric method described by Easly *et al.* [10]; phosphorus was analyzed by the spectrophotometric procedure outlined by Boltz *et al.* [11];and nitrogen ADF was determined by the method described by Guering *et al.* [9]. Treatment differences in weight gain, water intake and mineral consumption were tested independently for heifers and steers by a student t-test [12] at the 0.05 level of significance.

The economic analysis was conducted according to the method suggested by the Centro Internacional para el Mejoramiento del Maiz y del Trigo (CIMMYT) [13] that compares the costs that vary with the net benefits. This comparison is important for cotton farmers as well as for cow–calf producers because they are interested in assessing the increase in costs required to obtain a given increase in net benefits and, in the future, to reach sustainability of the system.

3 RESULTS AND DISCUSSION

The total cotton residues in the field were estimated at 2,100 kg ha^{-1} of DM. The residues consisted of leaves, stem materials, cottonseed hulls, motes (immature seeds) and cotton fibers. The results of the nutritional analyses of both cotton leaves and cotton hulls are shown in Table 1. The dry matter was similar for leaves and hulls, while CP content was greater in leaves (14.32%) than hulls (11.91%). The CP content of cotton in this study was greater than those reported for cotton plant by-products [14] or cotton gin trash [15]. Neutral detergent fiber and ADF concentrations were greater in cotton hulls (69.23% and 61.42%, respectively) than in leaves (44.23% and 35.69%, respectively). Neutral detergent fiber and ADF concentrations in hulls were comparable to previously published results [14]. No information was available about NDF and ADF concentrations in leaves.

Table 1: Analysis of leaf materials and hulls from a cotton field*.

	Leaf material	Hulls
Dry matter	93.30	93.90
Crude protein	14.32	11.91
Neutral detergent fiber	44.23	69.23
Acid detergent fiber	35.69	61.42
Cellulose	16.88	43.72
Lignin	16.66	15.64
Silica	3.23	<1
Calcium	5.71	1.28
Phosphorus	0.23	0.35
Nitrogen ADF	2.64	1.42

*Results are expressed on a DM basis.

Cellulose concentration was greater in hulls (43.72%) than in leaves (16.88%). The lignin percentages were similar for leaves (16.66%) and hulls (15.64%). The results of cellulose and lignin concentrations were similar to previous studies using cotton straw [16]. In this study, leaves and hulls contained different concentrations of calcium (5.71% and 1.28%, respectively) and phosphorus (0.23% for leaves and 0.35% for hulls). Other studies [3] reported 0.65% calcium, which differs from our results. These authors also reported 0.25% phosphorus in cotton by-products, which generally agrees with our results. In addition, this study found 1.42% nitrogen ADF for hulls and 2.64% for leaves.

Control steers had an ADG of 0.766 kg during the first 15 days. During the second period, the ADG was 0.233 kg. Overall, the control steers gained 0.500 kg day^{-1}. These results generally agree with those of Arndt and Richardson [17], who reported an ADG of 0.620 kg in steers fed with cotton gin trash. In contrast, supplemented steers had an ADG of 0.433 kg during the first period, 0.500 kg during the second period and 0.466 kg overall. In these results, no significant differences were found for the two treatments using steers.

Weight change in females significantly differed from males. Control heifers gained 0.166 kg day^{-1} during the first period and 0.366 kg day^{-1} during the second period, with an overall mean gain of 0.266 kg day^{-1}. Supplemented heifers lost 0.166 kg day^{-1} during the first period and gained 0.633 kg day^{-1} in the second period. Overall, supplemented heifers gained 0.233 kg day^{-1} during the 30-day period. Differences in weight were not detected between supplement treatments. These results may be supported by earlier reports that showed that pure cellulose is equal to starch for fat production [18], while another researcher observed an increase in digestibility of cellulose when fed in the isolated form [19]. Indeed, these results allow us to answer the question asked by the cotton farmers in Mexico concerning the advantage of supplementing calves on cotton residues.

Water intake was not significantly affected by treatment. Control animals each drank an average of 13.0 L day^{-1}, while supplemented animals consumed about the same amount (13.2 L). It was noted that at the beginning of the study, calves in the control treatment had a tendency to drink more water than calves in the supplement treatment.

Mineral consumption was significantly affected by treatment. Control calves consumed a mean of 21 g day^{-1}, while supplemented animals consumed an average of only 3 g day^{-1}. Based on visual observations, the animals tested did not appear to have any deleterious effects of grazing on cotton residues. On the other hand, cattle grazing on these residues provide an opportunity for cotton farmers to improve profitability.

4 CONCLUSION

Table 2 shows an economic analysis. Based on these data, it seems reasonable that a livestock producer may benefit from grazing cattle on cotton residues without offering commercial supplements, like the supplement we used, although $4.00 per animal ($38 Mexican pesos) must be invested. Additionally, it would be more profitable for producers to have steers grazing these pastures rather than heifers. The practice of grazing steers without supplement would give a net benefit of $15.51 ($147.34 Mexican pesos) per animal, while offering a commercial supplement resulted in a net profit of only $6.07 ($57.66 Mexican pesos). This practice will allow sustainability of the cotton production.

Table 2: An economic analysis of grazing steers and heifers in a cotton harvested field[a].

	Steers		Heifers	
	Cotton residues	Cotton residues plus supplement	Cotton residues	Cotton residues plus supplement
Average gain per animal (kg)	15.00	13.98	7.98	6.99
Adjusted yield (kg animal^{-1})[b]	13.50	12.59	7.19	6.30
Field price ($ kg^{-1})[c]	12.00	12.00	10.00	10.00
Gross field benefit ($ kg^{-1})	**162.00**	**150.08**	**71.90**	**63.00**
Variable costs				
Parasiticide (ml)	3	3	3	3
Cost of parasiticide ($ ml^{-1})	3.00	3.00	3.00	3.00
Total cost of parasiticide ($)	9.00	9.00	9.00	9.00
Vitamin (ml)	4	4	4	4
Cost of vitamin ($ ml^{-1})	2.00	2.00	2.00	2.00
Total cost of vitamin ($)	8.00	8.00	8.00	8.00
Minerals (g)	630	90	630	90
Cost of minerals ($ g^{-1})	0.002	0.002	0.002	0.002
Total cost of minerals ($)	1.26	0.18	1.26	0.18
Direct labor (days)	5	10	5	10
Cost of labor ($ day^{-1})	60.00	60.00	60.00	60.00
Total cost of labor (per animal)	15.00	30.00	15.00	30.00
Supplemental feed (kg animal^{-1})	0	1	0	1
Cost of feed ($ kg^{-1})	1.75	1.75	1.75	1.75
Total cost of feed (per animal–30 days)	0.00	52.50	0.00	52.50
Total of variable costs ($ per animal)	33.26	99.68	31.26	97.68
Net benefit ($ per animal)	**128.74**	**50.40**	**40.64**	**–34.00**

[a]All prices are in Mexican pesos (9.50 Mexican pesos per American dollar).
[b]Average gain (kg) adjusted 10% downward due to management differences with farmers.
[c]Mexican pesos per kilogram of live weight as an average of the price given last year.

According to previous research in grazing cotton residues [20], it was noticed that grazing reduced the number of adults of boll weevils (*Anthonomous grandis* Boheman) and pink bollworms (*Pectinophora gossypiella* Saunders). Therefore, the results presented here suggest that this practice may allow the farmers an additional profit by reducing pest infestation of the crop in the following year and create a more sustainable cotton production system.

REFERENCES

[1] Secretaría de Agsricultura, Ganadería y Desarrollo Rural (SAGAR), Estadísticas de producción, Anuario, Mexico City, D.F., Mexico, 2001.

[2] Conner, M.C. & Richardson, C.R., Utilization of cotton plant residues by ruminants. *J. Anim. Sci.*, **65**, pp. 1131–1138, 1987.

[3] Arndt, D.L., Richardson, C.R., Albin, R.C. & Sherrod, L.B., Digestibility of chemically treated cotton plant by-product and effect on mineral balance, urine volume and pH. *J. Anim. Sci.*, **51**, pp. 215–223, 1980.

[4] Axe, D.E., Dunbar, J.R., Addis, D.G., Clark, J.G., Curley, R.G. & Helmer, J.W., Feeding value of cotton gin trash in feedlot growing rations, Cattle Feeder's Day, University of California-Davis, Davis, CA, 1981.

[5] Ramalho, F.S., Cotton pest management: Part 4, A brazilian perspective. *Annu. Rev. Entomol.*, **39**, pp. 563–578, 1994.

[6] Salinas, G.H. & Saenz, E.P., Avances de Investigación Agrícola en zonas de riego y temporal. Campo Exp. La Laguna, Centro de Investigaciones Agricolas del Norte, Instituto Nacional de Iinvestigacionses Agricolas, Secretaria de Agricultura y Recursos Hidraulicos, Vol. 8, pp. 122–136, 1983.

[7] Ben-Ghedalia, D., Shefet, G. & Miron, J., Effect of ozone and ammonium hydroxide treatment on the composition and in-vitro digestibility of cotton straw. *J. Sci. Food Agric.*, **31**, pp. 1337–1342, 1980.

[8] AOAC, *Official Methods of Analysis of AOAC International*, 15th edn, Association of Official Agricultural Chemists: Washington, DC, 1990.

[9] Guering, H.K. & Van Soest, P.J, *Forage Fiber Analysis*, USDA Agr. Sci. Handbook, No. 379, Washington, DC, 1970.

[10] Easly, J.F., McCall, J.T., Davis, G.K. & Shirley, R.I., *Analytical Methods for Food and Tissues*, Nutrition Laboratory, Department of Animal Science, University of Florida, Gainesville, FL, 1965.

[11] Boltz, D.F. & Mellon, M.G., Spectrophotometric determination of phosphorous as molybdiphosphoric acid. *Anal. Chem.*, **20**, p. 749, 1948.

[12] Steel, R.G.D. & Torrie, J.H., *Principles and Procedures of Statistics a Biometrical Approach*, 2nd edn, McGraw-Hill: New York, NY, 1980.

[13] CIMMYT, *From Agronomic Data to Farmer Recommendations: An Economic Training Manual*, Vol. 1, Centro Internacional para el Mejoramiento del Maiz y del Trigo, Mexico City, D.F., Mexico, 1988.

[14] McCann, M.A., Craddock, B.F., Preston, R.L. & Ramsey, C.B., Digestibility of cotton plant by-product diets for sheep at two levels of intake. *J. Anim. Sci.*, **68**, pp. 285–295, 1990.

[15] Whiting, F.M. & Schuh, J.D., Use of cotton gin trash in the diets of growing dairy heifers. *Proceedings, Western Section, American Society of Animal Science*, Vol. 39, pp. 399–401, 1988.

[16] Miron, J.D. & Ben-Ghedalia, D., Effect of chemical treatment on the degradability of cotton straw by rumen microorganisms and by fungal cellulose. *Biotechnol. Bioeng*, **23**, pp. 2863–2865, 1981.

[17] Arndt, D.L. & Richardson, C.R., Digestibility by lambs and performance of lambs and steers fed sodium hydroxide-treated cotton plant by-product. *J. Anim. Sci.*, **54**, pp. 377–383, 1982.

[18] Woodman, H.E., & Evans, R.E., The nutritive value of fodder cellulose from wheat straw. I. Its digestibility and feeding value when fed to ruminants and pigs. *J. Agri. Sci.*, **37**, pp. 202–206, 1947.

[19] McNally, R.A., Digestion of straw by the ruminant. *Biochem. J.*, **36**, p. 392, 1942.

[20] Rodriguez, R. & Rubio, H.O., Incidencia de gusano rosado y picudo del algodón en variedades de tres niveles de maduración y su control con el pastoreo de bovinos en el esquilmo agrícola, Informe Técnico del proyecto PRECI, 2293, Chihuahua, Mexico, 2000.