Canola and Calves: An Integrated Crop-Livestock Farming System for Producing Canola and Stocker Cattle in the Southeast

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Abstract

Research was conducted to establish appropriate grazing management strategies that optimize stocker calf production and the seed yield of canola (*Brassica napus* L.). Sixteen 0.66-ha paddocks were blocked by previous tillage history and randomly assigned to one of four treatments, which included an ungrazed canola control (canola-no graze; CNG); canola lightly grazed with grazing terminated prior to growth stage (GS) 3.0 and a post-grazing residual of at least 1500 kg of dry biomass/ha (canola-early graze; CEG); canola heavily grazed with grazing terminated prior to GS 3.1 and a post-grazing residual of less than 1000 kg of dry biomass/ha (canola-late graze; CLG); and winter wheat grazed with grazing terminated prior to jointing (Feekes GS 6) and the post-grazing residual remains at a height greater than the height of the joint (WW). Angus steers (n=18; 248 ± 19 kg) were blocked by weight and randomly assigned to one of 12 grazing paddocks. Growth stage, leaf area index (LAI), near infrared light band (NIR), red light band (RED), normalized difference vegetation index (NDVI), and herbage mass were assessed at two week intervals. Estimated herbage mass was calculated weekly in all paddocks using a rising plate meter (RPM). Nutritive value of treatment samples was determined by near infrared reflectance spectroscopy. Calves were weighed on d 0 and 49. All treatments were harvested to determine total biomass, seed yield and oil percentage. Paddock was considered the experimental unit and steer was the observational unit. Grazing treatment did affect RPM estimated herbage mass ($P < 0.01$), NIR ($P < 0.01$), NDVI ($P < 0.01$), GS ($P < 0.01$) and seed yield ($P = 0.04$). RPM estimated herbage mass was higher ($P < 0.01$) in the WW paddocks compared to all canola treatments. ADG was similar across all treatments ($P > 0.53$). Seed yield was greatest ($P < 0.05$) for WW compared to all canola treatments; within canola treatments, CEG was greater than CLG, with CNG intermediate. These data show that implementation of appropriate grazing management strategies can optimize stocker calf production and not compromise seed yield and oil content of canola.

Problem Statement

Beef cow-calf operations represent the largest agricultural land use in major land resources areas (MRLA) for Southern Appalachian ridges and valleys and the Southern Piedmont. Pastures and hayfields in much of this region contain fescue, bermudagrass, or both (Ball et al., 2007). If canola production in the Southeast (SE) expands, it will likely be in pastures and hayfields converted to canola production. Forage production to fill the winter feed gap is a key objective of a dual-purpose crop (Kirkegaard, 2012).

Brassicas, such as canola (*Brassica napus* L.), can produce substantial amounts of herbage during the late fall and early winter. This is a time when established perennial forages begin to decline in nutritional value and yield, which is a critical period in the nutritional management of SE cow herds (Reid et al., 1994). Brassica crops are also palatable, have a low dry matter (DM) content, and low concentrations of cellulose and detergent fibers (Pelletier et al., 1976, Faix et al., 1979), which result in a forage that is highly digestible and can greatly increase animal performance. Recent research has shown that there may be the potential to utilize canola as a dual-purpose crop in integrated crop-livestock production systems (Heer et al., 2006; Kirkegaard et al., 2008; Stamm and Martin, 2011; Kirkegaard et al., 2012). Winter canola cultivars are grazed by cattle in the Great Plains region of the U.S., but the harsh winters can cause significant yield losses as a result of delayed maturity caused by grazing (Heer, 2006). In the SE region of the U.S., less severe winter conditions and a longer spring growing season provide a significant opportunity to produce more biomass for a longer winter grazing period and a longer period of plant recovery to increase seed yield in the spring.

In order to balance the value of the forage and oilseed yield, dual-purpose use of canola will rely on successful and timely establishment, an appropriate match of variety to environment, and careful grazing management (Kirkegaard et al., 2008). Previous literature has reported that lambs grazing dual-purpose canola in Australia grew 210 g per d in the winter (Kirkegaard et al., 2008). Kirkegaard et al. (2012) reported insignificant yield losses when terminating grazing prior to the Harper and Berkenhamp (1975) predicted growth stage 3.1 and favorable spring growing conditions followed. With favorable weather conditions and timely grazing management, there was little to no effect of winter grazing on canola seed yield (Kikegaard et al., 2008a; 2012). However, no literature is available evaluating canola as a dual-purpose crop for beef cattle production.

The goal of this research was to evaluate the potential of canola as a dual-purpose (forage and oilseed) crop in the SE. The objectives were to compare stocker cattle performance and oilseed yield of canola when grazing occurred and was terminated by the safe stage or the sensitive stage (as defined by Kirkegaard et al., 2012) relative to the oilseed yield of ungrazed canola and the cattle performance and grain yield of dual-purpose winter wheat.

Creative Research Approach

The experiment was conducted at the J. Phil Campbell, Sr. Research and Education Center in Watkinsville, GA.

Forage Management

Sixteen 0.66-ha paddocks were blocked by previous tillage history and randomly assigned to one of the four treatments: canola not grazed by steers (CNG); canola lightly grazed by steers with grazing terminated prior to growth stage (GS) 3.0 and a post-grazing residual of at least 1500 kg of dry biomass/ha (CEG); canola heavily grazed by steers with grazing terminated prior to GS 3.1 and a post-grazing residual less than 1000 kg of dry biomass/ha (CLG); and winter wheat grazed by steers with grazing terminated prior to jointing (Feekes GS 6) and the post-grazing residual remains at a height greater than the height of the joint (WW). Paddocks were sampled immediately prior to grazing initiation and throughout the grazing period to measure leaf area index (LAI), red light band (RED), near infrared light band (NIR), normalized difference vegetation index (NDVI), herbage mass, and GS. Leaf area index was non-destructively assessed using a handheld LI-COR LAI 2200 Plant Canopy Analyzer (LI-COR Biosciences, Lincoln, NE) remote sensing device. During this same time, a handheld CropCircle (Holland Scientific, Lincoln, NE) was used to measure the amount of RED and NIR reflected by the canopy and to calculate the NDVI

Following the remotely sensed measures of the canopy, herbage mass within the 0.1-m^2 area was assessed using a Filip's Manual Folding Plate Meter (Jenquip Agri-Business, New Zealand), otherwise known as a rising plate meter (RPM). These measurements were subsequently used to create a calibration equation (Eq. 3.2; R^2=0.67) that could be used to quantify available forage mass using subsequent RPM measurements throughout the paddock.

Eq. 3.2 $$\frac{Forage\ Yield\ (kg\ DM)}{ha} = (141.37 \times RPM) - 350.86$$

Growth stage of the crop with each 0.1-m^2 area was then recorded prior to destructive sampling. Growth stage assessments were conducted by a single observer for throughout the experimental period.

After all non-destructive samples were obtained; a destructive sample was hand-clipped to a stubble height of 3 cm in each randomly located 0.1-m^2 area for the purpose of quantifying herbage mass. Herbage mass from each destructive sample was collected for determination of DM content and nutritive value.

Animal Management

On 23 January, 16 steers (248 ± 19 kg) were weighed after fasting in a dry lot for a period of 12 hours, blocked by weight, and randomly assigned to one of the three grazing treatments (CEG, CLG, and WW). During the grazing experiment, mineral supplement was provided to the steers weekly at a rate 0.9 kg per hd per wk and the calves had *ad libitium* access to water and shade. At the termination of grazing, weights of the stocker calves were again obtained after fasting in a dry lot for a period of 12 hours.

Crop Management

Total biomass and seed production was assessed at the end of the experiment in three randomly located 0.5-m^2 areas in each paddock. The entire crop within each area was clipped to a 3 cm stubble height. All clipped biomass was placed on a tarp and weighed on a hanging scale immediately before the collected biomass was thrashed using Hege plot combine (Wintersteiger, Inc., Salt Lake City, UT). The seed collected was used to calculate seed yield for each paddock. Separated seed samples were submitted to Resaca Sun Feeds, LLC (Resaca, GA) for analysis of oil content via nuclear magnetic resonance (NMR) as described in Hocking et al. (1997a).

Results and Discussion

Forage Response

Despite different grazing management treatments, the average herbage mass was not different (P = 0.30) between all grazed treatments for the growing season. However, RPM estimated herbage mass was higher (P < 0.01) in the WW paddocks compared to all canola treatments. As assessed by the RPM, the CLG paddocks had less (P < 0.01) available forage (780 kg/ha vs. 1026 kg/ha and 922 kg/ha, respectively) than the CEG and CNG paddocks, which were not significantly different from each other (P > 0.10). Grazing treatment affected (P < 0.01) growth stage for the growing season with CLG values being the highest (GS 2.7), and CEG tending (P = 0.07) to be higher than CNG.

LAI was not affected (P = 0.09) by treatment for the growing season. Following the LAI trends, mean NDVI during the season was greatest (P < 0.01) for WW, lowest for CLG, and CNG and CEG being intermediate and similar to each other (Table 2). The mean NIR for the season was different (P < 0.01) among treatments with CNG being greatest and WW lowest. The mean RED reflectance showed no difference (P = 0.28) among treatments for the growing season.

Animal Response

Initial BW, final BW, and ADG was similar (P > 0.53) across all treatments. No other study has reported ADG for cattle grazing canola as a dual-purpose crop. The ADG reported for this study can only compare to forage brassicas and dual-purpose canola being grazed by sheep. . Kirkegaard (2008) observed 0.21 kg/d for sheep grazing dual-purpose canola, while Reid (2008) reported similar gains. Expressed as a percentage of BW, these gains are consistent with this current study. These gains would support necessary growth for a stocker operation.

Crop Production

Total biomass was not affected by treatment (P = 0.17). However, the management strategy for the canola affected (P = 0.04) seed yield with CLG and CNG resulting in lower seed yields than CEG. This increase in yield may be attributed to reduced biomass during the growing season, which can reduce crop height thereby reducing lodging. Lodging can restrict the movement of nutrients and water in the plant, and increase the incidence of fungal disease (Kirkegaard et al., 2012).There was no effect (P = 0.15) of treatment on oil content in the canola seed. These findings are consistent with previous studies by Kirkegaard et al. (2008a), which noted no difference in seed oil concentration due to grazing. Oil content is commonly influenced by temperature during pod fill, declining 2.7% for every 1 ºC increase in average temperature during seed filling (Hocking et al., 1997b). If flowering delays occur from grazing, it is possible to push flowering into the warmer portion of spring. However, the management strategies for grazing canola are designed to avoid such delays, minimizing an impact on seed yield or oil content.

Economic Returns

The value of gain in the calves was similar across all of the grazing treatments (P > 0.22). Crop value tended (P = 0.08) to be lower for CNG and CLG at $117.33/ha and $99.08/ha, respectively. Gross returns after establishment costs were similar across the grazing treatments, though each was greater (P =0.08) than CNG.

Conclusions

This research has shown that utilizing canola as a dual-purpose crop can be profitable. Weight gains for steers were similar to those of steers stickered on winter wheat. The management strategies used in the current experiment conserved seed yield and oil content. This research demonstrates that utilizing canola as a dual-purpose crop using grazing management similar to the CEG treatment can be profitable.

Table 1. The mean herbage mass (kg DM/ha) during the grazing period for the canola-no graze (CNG), canola-early graze (CEG), canola-late graze (CLG), and winter wheat (WW) paddocks immediately prior to grazing.

	Treatment					
Herbage Mass Assessment Method	CNG	CEG	CLG	WW	SE	P value
Bi-Weekly Clipped Mass, (kg DM/ha)	866	963	790	1020	115.3	0.2981
Weekly RPM Estimation, (kg DM/ha)	922[a]	1026[a]	780[b]	1164[c]	68.4	<0.0001

[a-c] Means within a row with different superscripts differ ($P < 0.05$).

[1] The herbage mass was assessed by bi-weekly hand clipping from three 0.1-m^2 areas/paddock and weekly measures of compressed sward height with a rising plate meter (RPM) in ca. 40 observation sites along a randomly located transect within each paddock and calculating the herbage mass using the calibration equation in Eq. 3.2.

Table 2. The mean crop canopy characteristics growth stage (GS), leaf area index (LAI), near difference vegetation index (NDVI), near infrared reflectance (NIR), and red reflectance (RED) during the grazing period for the canola-no graze (CNG), canola-early graze (CEG), canola-late graze (CLG), and winter wheat (WW) paddocks immediately prior to grazing. The data are presented as the mean of bi-weekly assessments from 23 January until 5 March.

	Treatment					
Item	CNG	CEG	CLG	WW	SE	P value
GS	2.5 [ac]	2.6 [c]	2.7 [b]	5.8 [a]	0.05	<0.0001
LAI	1.4	1.2	1.1	1.6	0.17	0.0901
NDVI	0.47 [b]	0.49 [ab]	0.46 [c]	0.54 [a]	0.01	<0.0001
NIR	2.6 [a]	2.1 [b]	2.2 [b]	1.9 [c]	.08	<0.0001
RED	3.2	3.2	3.4	3.4	0.10	0.2790

[a-c] Means within a row with different superscripts differ ($P < 0.05$)

[1] The data are presented as the mean of bi-weekly assessments from 23 January until 5 March.

Table 3. Body weight gains of stocker cattle grazing the canola-early graze (CEG), canola-late graze (CLG), and winter wheat (WW) treatments.

Item	Treatment			SE	P value
	CEG	CLG	WW		
Initial BW (kg)	249.7	247.1	244.6	5.83	0.8264
Final BW (kg)	299.6	309.6	306.8	0.07	0.5302
ADG (kg/d)	1.21	1.28	1.27	6.29	0.7750

[a-c] Means within a row with different superscripts differ ($P < 0.05$)

Table 4. The mean total aboveground biomass and seed yield produce by the canola-no graze (CNG), canola-early graze (CEG), canola-late graze (CLG), and winter wheat (WW) treatments, and oil content within the seed of the canola treatments.

Item	Treatment				SE	P value
	CNG	CEG	CLG	WW		
Total Biomass,(kg/ha)	7589.9	8731.2	5920.7	9002.3	1050.7	0.1712
Seed Yield, (kg/ha)	1466.6[ab]	2008.8[a]	1238.4[b]	2798.2[c]	245.8	0.0043
Oil Content, %	40.6	42.4	41.4	-	0.005	0.1476

[a-c] Means within a row with different superscripts differ ($P < 0.05$).

Table 5. Value of the calf and crop production and total gross returns for the canola-no graze (CNG), canola-early graze (CEG), canola-late graze (CLG), and winter wheat (WW) treatments.

	Treatment					
Item	CNG	CEG	CLG	WW	SE	P value
Calf Value[1]($/ha)	-	666.37	836.25	832.20	68.54	0.2160
Crop Value[2] ($/ha)	117.33	160.70	99.08	146.60	18.05	0.0874
Gross Return[3]($/ha)	36.39	746.13	854.39	877.63	176.75	0.0799

[a-c] Means within a row with different superscripts differ ($P < 0.05$).

[1] Based on $0.08/kg ($9.25/bu) canola and $0.05/kg ($5.25/bu) wheat.

[2] Based on $4.41/kg ($200/cwt) calf value.

[3] Gross return over establishment cost.

References

Ball, D., C. Hoveland, G. Lacefield. 2007. Southern Forages. 4th ed. International Plant Nutrition Institute. Norcross, GA.

Faix, J. J., C. Kaiser, D. Graffs, J. Lewis, M. Mansfield, G. Jung. 1979. Evaluation of various root crops, kale, and rape in sod seedings. Illinois Agric. Exp. Sta. Dixon Springs Agric. Ctr. 7:103-110.

Heer, W. F. 2006. Grazing winter canola in the southern Great Plains. *In* ‘Abstracts of ASA-CSA-SSSA 2006 International Annual Meetings’. 12-16 November, Indianapolis, USA. Available at: http://a-c-s.confex.com/crops/2006am/techprogram/P23808.HTM (accessed 20 August 2014).

Hocking, P.J., J.A. Kirkegaard, J.F. Angus, A.H. Gibson, and E.A. Koetz. 1997a. Comparison of canola, Indian mustard and Linola in two contrasting environments. I. Effects of nitrogen fertilizer on DM production, seed yield and seed quality. Field Crops Res. 49: 107–125.

Kirkegaard, J. A., S. Sprague, P. Hamblin, J. Graham, J. Lilley. 2012. Refining crop and livestock management for dual-purpose spring canola (*Brassica napus)*. Australian Journal of Crop and Pasture Science. 63:429-443.

Kirkegaard, J. A., S. Sprague, S. Pymer, P. Salisbury, B. Howlett. 2008. Dual-purpose canola- a new opportunity in mixed farming systems. Australian Journal of Experimental Agriculture. 59:291-302.

Pelletier, G., E. Donefer, J. Darisse.1976. Effects of dates of seeding and levels of N fertilization on yields, chemical composition and in vitro digestibility of forage kale. Can. J. Plant Sci. 56:63-70.

Reid, R. L., J. Puoli, G. Jung, J. Cox-Ganser, A. McCoy. 1994. Evaluation of Brassicas in Grazing Systems for Sheep: I. Quality of Forage and Animal Performance. J. of An. Sci. 72:1823-1831.

Stamm, M. 2011. K-State Research and Extension News. Available at: http://www.ksre.k-state.edu/news/story/winter_canola102611.aspx (accessed October 19, 2014).