Nutrient Uptake by Summer-active and Summer-dormant Tall Fescue in Northeast Mississippi

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- With approximately 600,000 acres of tall fescue in Mississippi, it is clearly the most important perennial cool-season grass. It grows especially well in the Prairie and Flatwood areas, where moisture is adequate during periods of maximum growth.
- The productivity and persistence of traditional, summer-active cultivars are compromised by high temperatures and soil moisture deficits common in summer months. The ability of cultivar 'Flecha' to be dormant in summer may improve persistence, but this trait may reduce dry matter (DM) yield.
- Manure saves nutrients for on-farm use as fertilizer. Recommendations for broiler litter use are to complete a P index risk assessment and base applications on either crop N or P use, or refrain from manure application if soil test P is "High". Information is needed on yields of biomass and nutrients with litter fertilization to minimize excess soil nutrients.
- Objectives were to determine litter rate effects on DM yield and nutritive value, as compared with commercial NPK fertilizer, and to compare nutrient uptake responses in summer-active and summer-dormant cultivars.

Materials and Methods

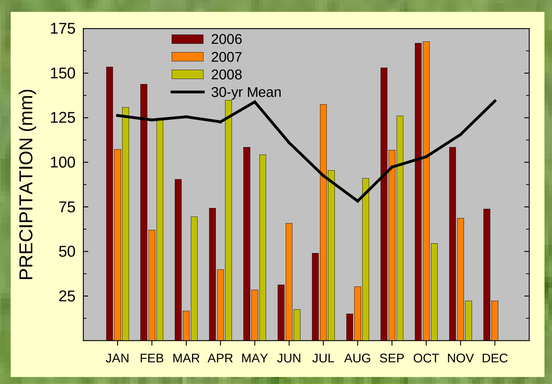
Site: Hay field at MAFES Research Center, Prairie, MS, within the northern part of the Blackland Prairie. The general weather pattern consists of wet winters and springs, and dry summers and autumns. The area (26 x 50 m) was cleared of vegetation and seed was drilled on 18 October 2004 at 28 kg ha^{-1}. Temperature and rainfall on site were recorded automatically (Onset Computer Corp., Bourne, MA).

Experimental Design: A split-plot randomized complete block was used with four replicates. The main plots consisted of five litter rates and a commercial fertilizer (CF) treatment. The sub-plots (each 2 x 5 m) consisted of three cultivars, summer-active Jesup and Kentucky 31, and summer-dormant Flecha. Kentucky 31 is a traditional Continental-type infested with the endophytic fungus, *Neotyphodium coenophialum*. Both Jesup and Flecha have the novel, non-toxic endophyte known as MaxQ (AR542).

Fertilization: Broiler litter was split-applied in October and April at 0, 4.5, 9.0, 13.4, and 17.9 Mg ha^{-1} yr^{-1} (as is moisture basis). The CF treatment provided 224 kg N ha^{-1} yr^{-1}, similar to 9.0 Mg litter ha^{-1}, and was a 2:1:2 ratio of N:P_2O_5:K_2O using ammonium nitrate, triple superphosphate and potash.

Forage: A 1- by 5-m swath was harvested at a 8.5-cm stubble height using a sickle-bar mower. Plots were harvested three times each year, at boot-stage in April and thereafter when regrowth height was 25-30 cm. Samples were collected to determine DM yield at 55 ^{o}C and ground to 1-mm size to determine nutritive value parameters by near infrared spectroscopy (NIRS) and nine elements by inductively coupled plasma spectroscopy (ICP). Nutrient uptake was estimated as the product of DM yield and nutrient concentration.

Soil: No history of broiler litter and mapped as a Houston clay (fine, montmorillonitic, thermic, Typic, Chromuderts). Soil tests in August 2004 recommended applications of N and P, but no K. Four, 2.5-cm diameter cores were obtained from each plot and dried in a glass house. Samples were analyzed for pH, total C and N using dry combustion method, and Mehlich-3 extractable nutrients using ICP.



Below normal rainfall was recorded in all three study seasons, with unusually droughty conditions in June to August 2006, March to June 2007, and June to July 2008.

In April and May, when tall fescue growth activity is typically high in the southeastern US, rainfall was 74, 27 and 96% of normal in 2006, 2007, and 2008, respectively.

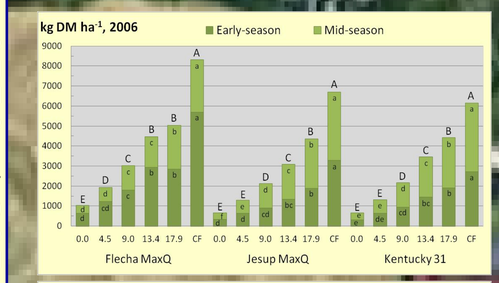
Amounts of nutrient elements applied in broiler litter through split applications in October 2005 to 2007 and April 2006 to 2008.

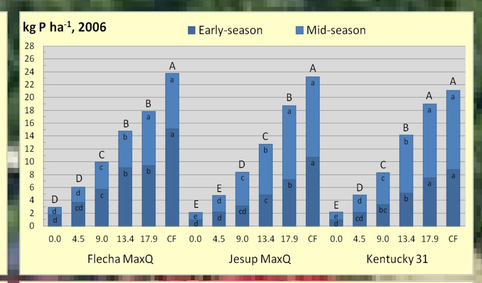
	Nitrogen	Phosphorus	Potassium
Autumn	---------- kg ha^{-1} ----------		
2.25	54	27	58
4.50	107	54	117
6.70	161	81	175
8.95	214	109	233
Spring			
2.25	56	27	54
4.50	113	54	108
6.70	169	81	162
8.95	225	108	216

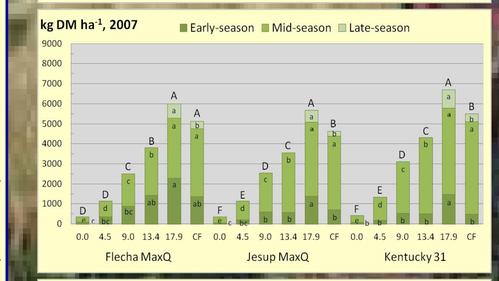
Soil chemical analysis to 15-cm depth for pH, total C, total N, and selected nutrient elements.

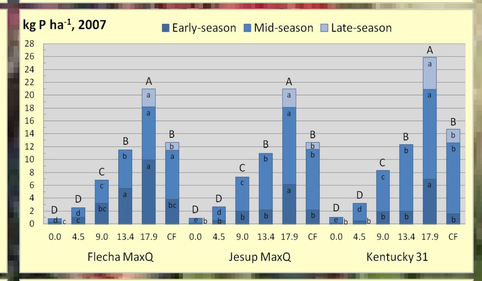
	pH	TC	TN	P	K	Cu	Zn
TRT		------- g kg^{-1} -------		---------- mg kg^{-1} ----------			
	---------- April 2006 (n=96) ----------						
CF	5.9	18.9	1.6	37 b	161 c	1.2 c	1.0 c
0	5.9	19.2	1.7	27 c	153 d	1.1 c	1.0 c
9.0	6.2	18.4	1.6	39 b	177 b	1.8 b	1.8 b
17.9	6.2	19.5	1.7	43 a	191 a	2.3 a	2.6 a
	---------- March 2007 (n=144) ----------						
CF	6.1 c	18.0 b	1.4 b	31 bc	138 bc	1.2 c	0.8 c
0	6.3 b	16.5 c	1.4 b	23 c	124 c	1.2 c	0.8 c
9.0	6.3 b	18.7 b	1.5 b	41 b	151 b	2.2 b	2.3 b
17.9	6.5 a	21.2 a	1.8 a	68 a	192 a	3.3 a	4.1 a
	---------- November 2008 (n=54) ----------						
CF	6.0 c	20.8 bc	1.7 c	40 d	149 c	1.2 e	0.9 e
0	6.2 b	19.9 c	1.8 bc	27 e	136 c	1.3 e	1.0 e
4.5	6.2 b	21.7 bc	1.9 bc	52 c	179 b	2.4 d	2.5 d
9.0	6.3 ab	21.4 bc	1.9 bc	63 c	176 b	3.0 c	3.6 c
13.4	6.4 a	21.8 b	2.0 ab	100 b	208 a	4.4 b	7.0 b
17.9	6.4 a	23.7 a	2.3 a	130 a	228 a	5.5 a	10.0 a

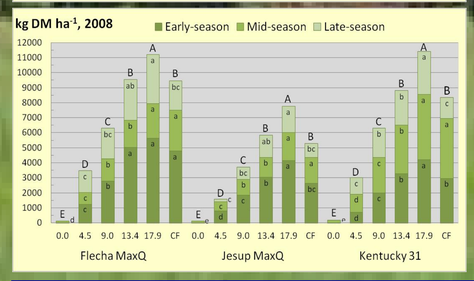
Means within a date with the same letter are not significantly different P = 0.05.

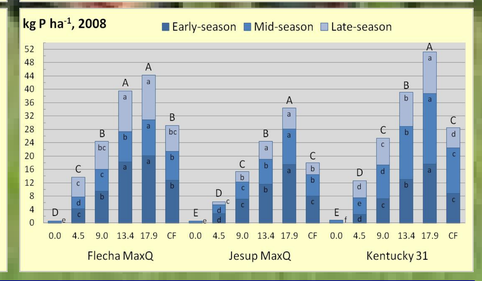












Litter rate and commercial fertilizer (CF) effects on seasonal and total DM yield and P uptake. Bars within a sampling date and cultivar with the same letter are not significantly different P = 0.05.

Main effects of fertility level, cultivar and year on sward height, forage CP concentration, in vitro true dry matter digestibility (IVTDMD), and acid detergent fiber (ADF) at early- and mid-season harvests in 2006 and 2007. Nutritive value parameters based on 'Mixed Hay' equation developed by NIRS Forage and Feed Testing Consortium (12MH50-2.eqa., 2013).

Harvest and parameter	Litter and commercial fertilizer (CF) treatment				Cultivar			Year	
	0 Mg ha^{-1}	9.0 Mg ha^{-1}	17.9 Mg ha^{-1}	CF	Flecha	Jesup	KY-31	2006	2007
Early-season (April)									
Forage height, cm	18 c	29 b	38 a	45 a	39 a	30 b	28 b	33	32
CP, g kg^{-1}	116 b	120 b	130 a	130 a	110 b	131 a	131 a	122	126
IVTDMD, g kg^{-1}	794	787	790	782	769 c	795 b	801 a	798 a	779 b
ADF, g kg^{-1}	337 b	342 ab	349 a	353 a	361 a	339 b	337 b	330 b	362 a
Mid-season (May)									
Forage height, cm	15 d	25 c	40 b	45 a	32	30	32	35 a	272 b
CP, g kg^{-1}	92 d	116 c	143 b	152 a	125 b	128 a	123 b	147	104
IVTDMD, g kg^{-1}	710 c	727 b	760 a	754 a	740	739	733	779 a	696 b
ADF, g kg^{-1}	400 a	384 b	366 c	360 c	380	373	379	356 b	399 a

Means within a sampling date and main effect treatment with the same letter are not significantly different P = 0.05. The fertility level by cultivar interaction affected (P < 0.01) CP at the early-season harvest; otherwise, the interaction was not significant (P > 0.10).

Results

- Severely limited regrowth did not permit a late-season harvest in 2006.
- When data for early- and mid-season harvests were averaged across 2006 and 2007, cumulative DM yield and N uptake were maximized with CF treatment.
  - Forage CP and uptake of P and K were maximized with CF and 17.9 Mg litter ha^{-1} treatments. These traits not affected by fertility treatment x cultivar interaction (P > 0.09).
  - Cumulative N uptake averaged 18 kg ha^{-1} with CF treatment and values increased linearly from 19 to 96 kg ha^{-1} across litter rates.
- Across four litter rates in 2008, the slope for CP concentration was relatively large in Kentucky 31 and Jesup, and not significant in Flecha. The ranking of slopes for DM and nutrient uptake was Kentucky 31 > Flecha > Jesup.
  - Poor productivity of Jesup appeared to involve damage from Benefin/Trifluralin applied in April to control crabgrass.
- Applying 9.0 Mg litter ha^{-1} yr^{-1} appeared to be the best compromise for high DM yield, nutritive value, and nutrient uptake, but elevated P, Cu, and Zn levels in surface soil.
- Soil tests in autumn 2008 indicated greater pH and Mehlich-3 extractable nutrients at the lowest litter rate of 4.5 Mg ha^{-1}, as compared with CF treatment.

Trends for changing cumulative DM yield, weighted-sum CP, and nutrient uptake in 2008 across four litter rates of 4.5, 9.0, 13.4, and 17.9 Mg litter ha^{-1} yr^{-1}.

Source	df	DM	CP	N uptake	P uptake	K uptake
		---------- F value ----------				
BL$_{linear}$†	1	353 **	16 **	495 **	266 **	160 **
BL$_{linear}$ x cultivar‡	3	226 **	6 *	271 **	178 **	304 **
		---------- Slope ----------				
Cultivar average	--	0.56	0.996	10.57	2.46	15.79
Flecha	--	0.59 **	0.52 ns	10.25 **	2.39 **	15.31 **
Jesup	--	0.46 **	1.30 **	9.21 **	2.08 **	11.85 **
Kentucky 31	--	0.62 **	1.17 **	12.25 **	2.90 **	20.21 **
		---------- Y-intercept ----------				
Cultivar average	--	0.44	99.74	-1.18	-0.43	-17.71
Flecha	--	1.38	89.36	4.68	2.92	-6.79
Jesup	--	-1.52	103.63	-28.99	-7.42	-64.79
Kentucky 31	--	1.14	101.67	17.64	4.51	31.78

† F-test null hypothesis: Slope coefficient for cultivars = zero.
‡ F-test null hypothesis: Slope$_{Flecha}$ = Slope$_{Jesup}$ = Slope$_{Kentucky31}$.
*, ** F value or slope coefficient significant at *P* <0.05 and *P*<0.01, respectively.

Summary

- Forage CP was approximately 100 g kg^{-1} with 9.0 Mg litter ha^{-1} and commercial fertilizer treatments; however, DM yield and P uptake were 2.2-fold greater with fertilizer.
- Greater biomass in Flecha than Jesup or Kentucky 31 was associated with lower (P < 0.01) K uptake and weighted-sum CP.
- Summer-dormant Flecha appeared to offer an early-season productivity benefit and annual nutrient uptake that was comparable to the two summer-active tall fescue cultivars.
- The forage from early- and mid-season harvests had digestibility levels that exceeded 700 g kg^{-1}, indicating all fertilization practices and cultivars enabled productive land for livestock production.
- Soil sample every 2 years to monitor P levels on fields where poultry litter is applied.

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