Considerations for Using Warm Season Annuals as Part of Your Forage System

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Warm Season Annuals

Interest in warm season annuals has increased in recent years due to:

- ✓ Prevented planting
- ✓ Drought
- ✓ Water availability
- ✓ Additional forage production
- ✓ Improved varieties and quality
- ✓ Labor and equipment availability
- ✓ Other.

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Warm Season Annuals

PROS:

- \+ Drought tolerant
- \+ Tolerant of poorer soils
- \+ Shorter growing season
- \+ Less expensive vs. other forages (?)
- \+ Source of digestible fiber

CONS:

- \- Lower energy content than corn
- \- Non-BMR varieties can limit intake and production
- \- Limited weed control options
- \- Potential for nitrate or prussic acid toxicity
- \- Difficult to harvest as hay

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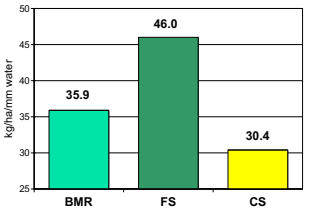
Forage Sorghum vs. Corn Silage

- ✓ Sorghum and millet require less water to produce a crop than corn.
- ✓ Normal forage sorghum is 51% and BMR 18% more efficient in utilizing water than corn for silage production



Miron et al., 2007. Anim. Feed Sci. Tech. 139:23-29.

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Part of the difference in water efficiency is due to differences in root structure. Corn roots do not grow as deep into the soil or as plentiful as sorghum or millet.

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Forage Sorghum vs. Corn Silage

- ✓ For similar yield, fertility requirements are similar for forage sorghum and corn except for K which is lower for forage sorghum
- ✓ Seed cost per acre are lower for forage sorghum.
- ✓ Considerable variation in yield and quality among available hybrids.

	Corn	FS
	---- lb/acre ----	
N	202	212
P_2O_5	92	77
K_2O_5	212	80

Fertilizer requirements based on yield of 25.5 t/acre at 35 % DM.

Bean and Marsalis. 2012. High Plains Dairy Conf. 87-94.

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Breeding programs have developed varieties with higher quality and improved traits

- ✓ Brown midrib (BMR)
  - Lower lignin concentrations
  - Higher NDF digestibility
  - ±10% yield drag
  - Increased lodging potential
- ✓ Brachytic dwarf
  - Reduced lodging potential

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Breeding programs have developed varieties with higher quality and improved traits

- ✓ High sugar or sweet varieties
  - Improved fermentation when ensiled
  - Higher energy potential
- ✓ Photosynthetic sensitive (PS)
  - Delayed flowering
  - Higher yield
  - Improvements in quality have not been consistently observed compared with normal or BMR varieties

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Should I consider growing warm season annuals?

What are your needs and options?

- Agronomic factors
  - Soil fertility
  - Weed control
- Water supply
- Growing season
- Forage inventory
  - Lactating cows vs. dry cows and heifers
- Other

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Warm Season Forage Options

- ✓ Forage sorghum
- ✓ Sorghum-sudan grass
- ✓ Sudan grass
- ✓ Millet
- ✓ Forage soybeans
- ✓ Cowpeas
- ✓ Others

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Chemical Composition

Item	Corn Silage	Forage Sorghum	BMR Forage Sorghum	Sorghum Sudan	Sudan	Forage soybeans
No. samples	3,285	3,230	339	848	890	88
DM	34.3	39.3	27.3	46.0	863	50.4
CP	8.03	**10.5**	**11.6**	**12.0**	**11.8**	**18.7**
NDF	40.4	**56.4**	**56.9**	**60.1**	**60.8**	46.7
30 h NDFD	55.0	54.4	**64.5**	53.9	57.7	**40.7**
Lignin	3.18	4.84	3.66	4.47	4.72	8.23
Sugar	2.05	0.53	0.33	0.87	1.63	5.15
Starch	33.2	**7.32**	**4.10**	**2.11**	**1.83**	**2.05**
EE	3.08	2.86	3.02	3.00	2.89	**11.9**
Ash	3.9	**10.1**	**8.08**	**11.2**	**12.0**	**10.4**

Samples submitted to Cumberland Valley Analytical Services from 1/1/20 through 8/1/21.

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Effect of energy supplement and blend of forage sorghum and ryegrass silage on performance

	50:50 FS:RS			75:25 FS:RS			
	GC	HF	B	GC	HF	B	SE
DMI, lb/d	52.7	53.8	50.3	51.8	51.4	50.5	1.8
Milk, lb/d	72.3	73.4	71.0	75.4	73.0	76.5	2.0
Fat, %	3.82	3.78	3.87	4.22	4.11	3.93	0.22
Protein, %	2.83	2.80	3.05	2.84	2.90	2.80	0.05
ECM, lb/d[a]	73.4	74.1	73.6	80.5	77.2	78.5	2.9
EFF[a]	1.39	1.38	1.46	1.55	1.50	1.56	0.03

[a]Forage effect ($P < 0.05$).

GC = ground corn; HF = hominy feed; and B = 50:50 blend of ground corn and hominy feed. Diets contained ~40% forage with 34 to 35.5% NDF. Starch concentrations averaged 21% for 50:50 and 24.5% of 75:25 diets

Boyd et al. 2008. Prof. Anim. Sci. 24:349-354.

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In vitro digestion kinetics of NDF

Item	Normal sorghum	BMR sorghum	Alfalfa	Corn	SE
Lag, /h	5.7^{a}	3.6^{ab}	2.6^{b}	1.8^{b}	1.7
Kd, h^{-1}	0.057	0.061	0.050	0.071	0.006
30 h IVNDF, %	40.1^{d}	49.2^{c}	51.6^{c}	47.8^{c}	0.5
Extent of digestion, %	55.8^{e}	60.6^{d}	66.1^{c}	55.7^{e}	0.7

^{ab}Means in the same row with unlike superscripts tend to differ ($P < 0.10$).
^{cde}Means in the same row with unlike superscripts differ ($P < 0.05$).
Aydin et al., 1999. JDS 82:2127-2135.

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Effect of forage source on performance[1,2]

	Norm	BMR	Alfalfa	Corn	SE
NDF, % of DM	39.7	40.3	29.1	34.3	
DMI, lb/d	47.4	50.0	52.9	55.8	0.9
Milk, lb/d	47.4^{c}	53.6^{b}	55.6^{b}	65.0^{a}	1.1
Fat, lb/d	1.74^{c}	1.76^{b}	2.09^{b}	2.47^{a}	0.07
Protein, lb/d	1.50^{c}	1.72^{b}	1.74^{b}	2.18^{a}	0.0
4% FCM, kg/d	45.6^{c}	52.2^{b}	54.0^{b}	63.9^{a}	1.3
Efficiency	0.94^{c}	1.05^{b}	1.05^{b}	1.15^{a}	0.03

^{abc}Means in the same row with unlike superscripts differ ($P < 0.05$).
[1]Diets were formulated with 65% forage from normal forage sorghum, BMR forage sorghum, alfalfa, or corn silage and 35% concentrate.
[2]Aydin et al. 1999. J. Dairy Sci. 82:2127-2135.

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Effect of forage source on performance[1,2]

	Norm	BMR	Corn	SE
NDF, % of DM	32.3	31.6	31.9	
DMI, lb/d	52.2	55.3	54.7	2.2
Milk, lb/d	74.5^{b}	79.4^{a}	76.3^{ab}	1.5
Fat, %	3.54	3.59	3.57	0.14
Protein, %	2.99	3.08	3.01	0.04
4% FCM, lb/d	69.2^{b}	74.5^{a}	71.4^{b}	1.5
Efficiency	1.30^{b}	1.36^{a}	1.31^{b}	0.05

^{abc}Means in the same row with unlike superscripts differ ($P < 0.05$).
[1]Diets were formulated with 17.5% alfalfa silage plus 35.3% from either normal forage sorghum, BMR forage sorghum, or corn silage.
[2]Aydin et al. 1999. J. Dairy Sci. 82:2127-2135.

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Chemical composition of corn (CS) and Brachytic dwarf BMR forage sorghum (FS) harvested in the summer (S) or fall (F).

	CSS	CSF	FSS	FSF
DM, %	46.6	29.6	28.7	29.7
	---------- % of DM ----------			
CP	8.0	8.5	9.0	9.5
NDF	39.0	38.3	54.2	55.1
ADF	24.5	24.0	35.9	36.0
Ether extract	3.4	3.6	3.5	3.0
Sugar	1.4	1.0	2.2	1.6
Starch	37.2	34.0	16.8	14.1
Starch dig., 7 h	74.0	82.6	64.3	76.8
Ash	3.20	4.19	5.03	4.73

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Production response of lactating cows to diets based on corn (CS) or BMR forage (FS) sorghum harvested in the summer (S) or fall (F)

	CSS	CSF	FSS	FSF	SE	P
DMI, lb/d	49.4	47.2	48.5	45.4	2.2	0.58
Milk, lb/d	73.4	75.0	75.2	75.6	2.9	0.95
Fat, %	3.26	3.07	3.39	3.48	0.14	0.20
Protein, %	2.75	2.66	2.61	2.66	0.04	0.13
Lactose, %	4.65	4.72	4.69	4.72	0.03	0.36
SNF, %	8.30	8.29	8.19	8.27	0.06	0.54
ECM, lb/d	70.3	69.4	72.5	74.1	3.1	0.78
Efficiency	1.43	1.48	1.50	1.63	0.08	0.24
MUN, mg/dl	11.2^{a}	14.3^{b}	16.0^{b}	15.8^{b}	0.83	0.001

^{ab}Means with unlike superscripts in the same row differ (P < 0.01)

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Production response of lactating cows to diets based on corn (CS) or BMR forage sorghum (FS) harvested in the summer (S) or fall (F) – Year 2

	CSS	CSF	FSS	FSF	SE	P
DMI, lb/d	55.1	49.6	51.6	51.1	2.2	0.30
Milk, lb/d	78.5	76.1	74.5	78.7	2.4	0.56
Fat, %	3.61^{d}	3.26^{c}	3.70^{d}	3.67^{d}	0.12	0.06
Protein, %	2.55	2.62	2.57	2.63	0.03	0.13
Lactose, %	4.68	4.67	4.74	4.72	0.02	0.14
SNF, %	8.07	8.09	8.13	8.15	0.04	0.68
ECM, lb/d	76.3	78.0	72.1	80.0	2.2	0.15
Efficiency	1.37	1.48	1.46	1.48	0.04	0.26
MUN, mg/dl	8.21^{a}	8.84^{a}	11.53^{b}	11.44^{b}	0.31	<0.0001

^{ab}Means with unlike superscripts in the same row differ (P < 0.01)
^{cd}Means with unlike superscripts in the same row differ (P < 0.01)

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Meta-analysis comparing normal forage sorghum (FS) or corn silage (CS) with BMR forage sorghum

Item	FS vs. BMR	*P*	CS vs. BMR	*P*
DMI, lb/d	-1.82	0.09	2.27	0.46
Milk, lb/d	-3.62	<0.001	0.35	0.74
Fat, %	-0.09	0.03	-0.10	0.009
Fat, lb/d	-0.18	<0.001	-0.04	0.52
Protein, %	-0.05	0.26	0.06	0.0003
Protein, lb/d	-0.09	<0.003	0.07	0.11
Lactose, %	-0.06	0.25	0.03	0.96
Lactose, lb/d	-0.35	0.02	0.18	0.07

9 trials comparisons for normal forage sorghum silage and 13 trial comparisons for corn silage versus BMR forage sorghum
Sánchex-Duarte et al. 2019. J. Dairy Sci. 102:419-425

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Whole plant grain sorghum silage (GS) compared with corn (CS) or normal forage sorghum silage (FS)

	CS	GS	FS	SE	P
DMI, lb/d	44.1	44.1	40.1	1.1	0.07
Milk, lb/d	56.0^{a}	54.2^{ab}	52.0^{b}	0.9	0.05
Fat, %	4.08	4.33	4.16	0.08	0.14
Fat, lb/d	2.27	2.20	2.16	0.4	0.09
Protein, %	3.36	3.28	3.31	0.07	0.31
Protein, lb/d	1.87^{a}	1.79^{ab}	1.70^{b}	0.04	0.05
4% FCM, lb/d	56.4	56.9	53.1	1.10	0.07
Efficiency	1.28	1.29	1.32	0.03	0.63
MUN, mg/dl	10.7^{a}	11.9^{ab}	12.9^{b}	0.02	0.05

^{ab}Means in the same row with different superscripts differ (*P* < 0.05).
Colombini et al., 2012. J. Dairy Sci. 95:4457-4467.

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BMR sorghum-sudangrass compared with corn silage

- ✓ Forage provided 35 or 45% of DM. Alfalfa-grass silage provided 9.4 or 9.6% of DM.
- ✓ Diets with BMR SS had higher fiber concentration and lower NFC/starch concentrations.

Composition of experimental forages

	BMR SS	Corn
DM	28.2	37.7
CP	10.8	7.2
ADF	41.6	21.0
NDF	66.2	36.8
Starch	1.1	42.7
Sugar	4.8	2.7
NFC	13.9	49.6
NDFD, 30 h	58.3	46.0

Dann et al., 2008. J. Dairy Sci. 91:663-672.

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BMR sorghum-sudangrass compared with corn silage

	35SS	45SS	35CS	45CS	SE
NDF, % of DM	40.3	48.2	31.1	34.2	
DMI, lb/d	44.3^{b}	38.8^{c}	51.6^{a}	51.1^{a}	1.3
Milk, lb/d	69.0^{ab}	63.7^{b}	72.1^{a}	68.1^{ab}	2.0
Fat, %	3.43	3.43	3.15	3.15	0.11
Fat, lb/d	2.29	2.16	2.20	2.14	0.11
Protein, %	2.95^{a}	2.81^{b}	3.00^{a}	3.00^{a}	0.03
Protein, lb/d	1.94^{b}	1.74^{c}	2.14^{a}	1.98^{ab}	0.04
MUN, mg/dl	11.96^{ab}	12.81^{a}	10.59^{b}	9.53^{b}	0.50
3.5% FCM, lb/d	67.0	62.6	67.0	64.2	2.4
Efficiency	1.52^{a}	1.62^{a}	1.32^{b}	1.26^{b}	0.05

^{ab}Means in the same row with different superscripts differ ($P < 0.05$).
Dann et al., 2008. J. Dairy Sci. 91:663-672.

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Sugar cane aphids

- 2013: First reports of the sugar cane aphid infesting sorghum in the US
- The aphid had a significant negative impact on all forages in the sorghum family
- Sugar cane aphids do not affect pearl millet.

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Sugar cane aphid

- Plant breeders have worked to identify varieties that are tolerant to sugar cane aphids
- Tolerance ratings are reported for varieties used for forage and grain production
  - No varieties are resistant to sugar cane aphids

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Sugar cane aphid control

- ✓ Control Johnsongrass – host for overwintering
- ✓ Plant varieties with tolerance that are suited to your area
- ✓ Plant early
- ✓ Plant seed treated with a registered neonicotinoid insecticide
- ✓ Scout early and often
- ✓ Treat with approved insecticide (check for those approved in your state)

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Corn silage vs. regular or sweet millet

	Corn	Millet		
	Silage	Regular	Sweet	SE
DM	34.7	26.1	25.3	
CP	9.6	12.8	13.4	
NDF	35.6	58.4	60.1	
Lignin	1.8	2.5	2.6	
DMI, lb/d	53.8[a]	50.0[b]	50.3[b]	1.3
Milk, lb/d	77.6[a]	72.1[b]	75.0[ab]	3.5
Fat, %	4.09	4.25	4.27	0.18
Protein, %	3.30[a]	3.04[c]	3.14[b]	0.09
MUN, mg/dl	8.6[b]	10.1[a]	10.8[a]	0.88

[abc]Means with different superscripts in the same row differ (P < 0.05).
Brunette et al. 2014. J. Dairy Sci. 97:6440-6449.

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Effect of substituting BMR dwarf pearl millet for corn silage

	CS	PM	SEM	P
DMI, lb/d	64.2	63.9	1.4	NS
Milk, lb/d	113.1	109.3	4.5	<0.001
Fat, %	3.47	3.71	0.12	0.06
Fat, lb/d	3.95	4.01	0.20	NS
Protein, %	2.86	2.85	0.05	NS
Protein, lb/d	3.22	3.15	0.12	NS
ECM, lb/d	103.2	102.7	4.2	NS
Efficiency	1.59	1.56	0.05	NS

BMR dwarf pearl millet replaced 10% of the ration DM provided by corn silage. Pearl millet was harvested at flag leaf (~12 inches of height) and wilted to 30% DM.
Harper et al. 2018. J. Dairy Sci. 101:5006-5019

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Response of cows fed diets based corn silage plus either BMR pearl millet silage (PM) or BMR forage sorghum silage (FS)

Item	PM	FS	SE	P
DMI, lb/d	58.0	58.4	1.3	0.89
Milk, lb/d	79.6	81.4	1.5	0.44
Fat, %	3.42	3.48	0.09	0.63
Protein, %	2.78	2.78	0.03	0.95
Lactose, %	4.79	4.72	0.03	0.10
SNF, %	8.47	8.46	0.04	0.84
ECM, lb/d	78.3	80.5	2.2	0.70
Efficiency	1.35	1.38	0.04	0.77
MUN, mg/dL	14.27	16.72	0.32	<0.0001

PM or FS provided 20.6% of DM and CS provided 32.6% of DM
Bernard and Tao. 2020. Appl. Anim. Sci. 36:2-7

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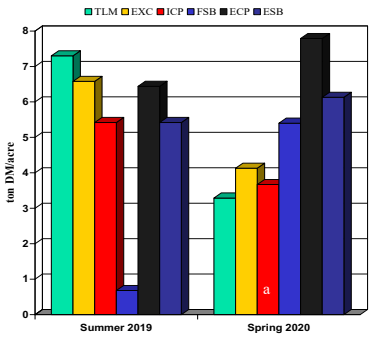
Yield of Tiftleaf (TLM) or Exceed (EXC) pearl millet, iron clay peas (ICP), forage soybeans (FSB), and combinations of ESC and ICP (ECP) or EXC plus FSB (ESB)



Summer crop was planted in August and the spring crop was planted in May into a sandy loam soil and fertilized according to UGA recommendations. No irrigation was provided.

[a]Cowpeas were 100% lodged preventing harvest

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Chemical composition of pearl millet (PM) or BMR pearl millet (BMR) pearl millet, cow peas (CP), forage soybeans (SB), and combinations of BMR and CP (BCP) or BMR plus FS (BSB)

Item	PM	BMR	SB	BCP	BSB	SEM
DM, %	44.80^{ab}	47.81^{c}	45.29^{bc}	48.61^{c}	42.39^{a}	0.99
	---------- % of DM ----------					
CP	9.82^{a}	9.72^{a}	18.53^{d}	11.39^{b}	13.84^{c}	0.19
ADF	37.56^{c}	33.35^{a}	38.58^{d}	34.19^{a}	35.67^{b}	0.31
aNDF$_{OM}$	69.97^{d}	67.35^{c}	56.04^{a}	64.76^{b}	63.49^{b}	0.66
EE	1.88^{a}	2.40^{b}	1.71^{a}	2.58^{b}	2.53^{b}	0.10
pH	4.07^{ab}	4.15^{b}	4.27^{bc}	4.00^{a}	4.20^{bc}	0.05
Ammonia, % of CP	25.92^{ab}	32.43^{a}	25.02^{ab}	29.03^{ab}	24.58^{b}	1.96

[abcd]Means with unlike superscripts in the same row differ ($P < 0.05$)
Results for spring 2020 crop

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Factors to consider

- ✓ Yield varies greatly among varieties
- ✓ Yield drag is not as bad for some BMR varieties, but BMR varieties do not perform as well under drought conditions.
- ✓ Varieties differ in sugar cane aphid tolerance
- ❖ Do your homework on variety selection

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Factors to consider

- ✓ Harvest grain or forage sorghum in early dough stage of maturity.
- ✓ Millet, sorghum-sudan and sudangrass should be wilted to promote a desirable fermentation.
- ❖ Nitrate and prussic acid concentrations should be measured in crops that are stressed by drought, frost, insect damage, etc. prior to harvest.
  - Delaying harvest for 7 days will greatly reduce concentrations.
  - Fermentation will decrease concentrations, but not eliminate.
  - Harvesting as hay does not alter concentrations.

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Factors to consider

- BMR varieties are better suited for lactating cows, especially high producing cows.
- Balance rations for NDF and metabolizable energy to maintain higher milk yield.
- Non-BMR varieties are better suited for diets where intake and energy density are not limiting

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Summary

While corn silage and alfalfa will continue as the King and Queen of forages, summer annual forages can be used as part of a forage program to feed lactating cows as well as dry cows and replacements, especially in regions where water is less abundant to support growth of corn or alfalfa

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