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# Forage Sorghum and Corn Silage Response to Full and Deficit Irrigation

I. Kisekka
*Kansas State University*, ikiskka@ksu.edu

J. D. Holman
*Kansas State University*, jholman@ksu.edu

J. W. Waggoner
*Kansas State University*, jwaggon@ksu.edu

J. Aguilar
*Kansas State University*, jaguilar@ksu.edu

***See next page for additional authors***



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**Abstract**
There is limited information on forage sorghum and corn silage yield response to full and deficit irrigation in Kansas. The objective of this study was to generate information on forage sorghum (brown mid-rib hybrids (BMR and non-BMR)) and corn silage yield response to different levels of irrigation as influenced by irrigation capacity in southwest Kansas. Preliminary results indicate the effect of irrigation capacity on forage yield was significant ($P = 0.0009$) in 2014 but not 2015, probably due to high growing season rainfall received in 2015. Corn silage produced significantly ($p < 0.05$) higher biomass at all irrigation capacities compared to forage sorghum hybrids in 2015. BMR forage sorghum produced significantly lower biomass compared to non-BMR hybrid in both 2014 and 2015 ($P < 0.05$). The highest amounts of forage produced for corn silage, BMR, and non-BMR forage sorghum were 24.6, 17.4, and 21.1 tons/a adjusted to 65%, moisture respectively. Water productivity ranged from 1.0 to 1.4 dry matter tons/a/in. More research is needed under normal and dry years to quantify forage sorghum and corn silage yield and forage quality response to full and deficit irrigation.

**Keywords**
forage sorghum, corn silage, full and deficit irrigation, irrigation management, crop water use, non-BMR forage sorghum, BMR forage sorghum



**Cover Page Footnote**
The authors would like to thank the Ogallala Aquifer Program for providing funding. We would also like to express our appreciation to Advanta Seeds US for providing seed for the study. The authors would also like to thank Mr. Dennis Tomsicek and Mr. Jaylen Koehn for implementing the research protocols, data collection, management of irrigation, and other agronomic field operations.

**Authors**
I. Kisekka, J. D. Holman, J. W. Waggoner, J. Aguilar, and R. Currie

# Forage Sorghum and Corn Silage Response to Full and Deficit Irrigation

*I. Kisekka, J. Holman, J. Waggoner, J. Aguilar, and R. Currie*

## Summary

There is limited information on forage sorghum and corn silage yield response to full and deficit irrigation in Kansas. The objective of this study was to generate information on forage sorghum (brown mid-rib hybrids (BMR and non-BMR)) and corn silage yield response to different levels of irrigation as influenced by irrigation capacity in southwest Kansas. Preliminary results indicate the effect of irrigation capacity on forage yield was significant ($P = 0.0009$) in 2014 but not 2015, probably due to high growing season rainfall received in 2015. Corn silage produced significantly ($p < 0.05$) higher biomass at all irrigation capacities compared to forage sorghum hybrids in 2015. BMR forage sorghum produced significantly lower biomass compared to non-BMR hybrid in both 2014 and 2015 ($P < 0.05$). The highest amounts of forage produced for corn silage, BMR, and non-BMR forage sorghum were 24.6, 17.4, and 21.1 tons/a adjusted to 65%, moisture respectively. Water productivity ranged from 1.0 to 1.4 dry matter tons/a/in. More research is needed under normal and dry years to quantify forage sorghum and corn silage yield and forage quality response to full and deficit irrigation.

## Introduction

A significant proportion of forages produced in Kansas are produced under irrigation. Diminishing well capacities coupled with frequent droughts have made it difficult for forage producers to meet demand from the beef and dairy industries. While grains can be brought in from other states within the U.S. grain belt, forages have to be produced locally due to their low bulk density and high transportation costs. For a long time, corn silage has been reliable forage for cattle feeders and dairies in the Great Plains, including Kansas, but with diminished well capacities many producers feel they cannot grow corn silage anymore. There is an urgent need to identify alternative drought tolerant high yielding forage crops that can be grown for silage with less water. Forage sorghum especially offers the potential to be an excellent silage option in the place of corn silage. Brown mid-rib (BMR) varieties on average have reduced lignin content compared to non-BMR varieties and tend to have higher digestibility and energy content. They can yield less than non-BMR varieties (Bean and Marsalis, 2012). There is limited information on forage sorghum yield response to limited irrigation under Kansas soils and climatic conditions. Further, there is particular interest in how BMR and conventional forage sorghum varieties respond to water. Therefore, the objective of this study was to generate information on forage sorghum yield response to full and deficit irrigation, and water productivity of corn silage, BMR, and non-BMR forage sorghum varieties.

# Procedures

## *Experimental Design*

The study was conducted at the Kansas State University Southwest Research and Extension Center (38° 01' 20.87" N, 100° 49' 26.95" W, elevation of 2910 feet above mean sea level) near Garden City, Kansas. The soil at the study site is a deep, well drained Ulysses silt loam. The experimental design was a split plot design with whole plots (irrigation capacity with 6 levels) arranged in a randomized complete block design, and crop was the subplot factor (three levels; corn silage, BMR, and non-BMR forage sorghum varieties) arranged as split plots within the whole plots as shown in Figure 1. The experiment was replicated four times.

## *Agronomic Management*

The experiment was conducted in a corn-forage sorghum rotation. The two forage sorghum hybrids planted in 2014 were Dyna-Gro F75FS13 non-BMR and F75FS28 BMR, both hybrids where medium maturity 95-110 days to soft dough. In 2015, corn silage was introduced into the experiment and the hybrid planted was DKC61-88 GENVT3P. Forage sorghum varieties planted in 2015 were Alta seeds AF7201 (BMR), medium-early 90-95 days to soft dough, and AF8301 (non-BMR), medium relative maturity 100 days. Planting was done using a Kinze no-till planter. Planting depth was 2 inches, corn silage seeding rate was 32,000 and forage sorghum seeding rate was 100,000 seeds per acre applied uniformly across all irrigation treatments. Corn silage was planted on May 14, 2015, and forage sorghum was planted on June 1, 2015. Fertilizer was applied preplant at a rate of 300 pounds of N per acre as urea 46-0-0. Weed control involved preplant application of 3 qt/a of Lumax EZ (S-metolachlor, atrazine, Mesotrione) and 2 oz/a of Sharpen (Saflufenacial), and 11 ounces of Starane Ultra (Pendimethalin) and 32 ounces Prowl H2O (Fluroxypyr) per acre applied post-emergence. Harvesting was done by hand at the soft dough stage by taking two 10-ft center rows. Samples were then oven-dried at 45°C for 48 hours to obtain weight on dry matter basis.

## *Irrigation Management*

Irrigation was applied using a linear move sprinkler system (Model: Valley 8000 series, Valmont Industries, Inc., Valley, Nebraska) with four spans and each span serving as a replicate. Irrigation treatments were designed to mimic the following irrigation capacities:

1. 4.6 gallons per minute (gpm)/a or 0.25 in./d
2. 3.9 gpm/a or 0.20 in./d
3. 3.1 gpm/a or 0.16 in./d
4. 2.3 gpm/a or 0.12 in./d
5. 1.5 gpm/a or 0.08 in./d
6. Near dryland (only 1 in. applied after emergence)

Irrigation was triggered whenever available soil water reached 60% in the top 4.0 feet of the soil profile, but irrigation frequency was limited by irrigation capacity. Soil water measurements were taken weekly using a neutron probe (CPN 503DR, CPN International, Concord, California) at one foot depth increments from 1 to 8 ft. Each irrigation event applied 1 inch for all treatments irrigated on a given day. At least 2 inches of preseason irrigation were applied to all treatments in 2014 and 2015.

Statistical analysis was implemented using the PROC GLIMMIX procedure in SAS studio (http://www.sas.com/en_us/software/foundation/studio.html ). Statistical tests were conducted at a 5% level of significance.

## Results and Discussion

### *May to October Seasonal Rainfall*

Rainfall during the 2014 and 2015 growing seasons from May 1 to October 31 exceeded long-term average in the same period from 1950 to 2013 as shown in Figure 2. The 2014 and 2015 summer growing season rainfall exceeded long-term average by 4.5 and 6 inches, respectively. The offseason rainfall for the 2014 and 2015 crops were 1.4 to 1.7 inches, respectively. Also, there were differences in seasonal distributions. In 2014, about 56% of the total rainfall from May to October 2014 was received in the month of June. A large rainfall event of 2.7 inches occurred on June 24 in less than 24 hours, which could have resulted in runoff. However, small slope (<3%) at the study site might have mitigated the runoff intensity. Above normal rainfall in May of 2015 ensured sufficient soil water at planting of forage sorghum. Better availability of water in July and August also improved yields in 2015.

### *Forage Sorghum Yield*

Average yields and seasonal irrigation for each treatment are summarized in Tables 1 and 2. The effect of irrigation capacity on forage yield was significant ($P = 0.0009$) in 2014 but not significant in 2015. This was due to differences in seasonal rainfall amount and distribution. While the total rainfall for the two growing seasons was not substantially different, 2014 was very dry earlier in the season until heavy rains were received in late June, which could have affected initial growth. The high-intensity storms resulted in deep drainage and runoff water losses in 2014. The effect of forage type on total aboveground biomass was significant ($P < 0.05$) in 2014 and 2015. However, the effect of interactions between irrigation capacity and forage type on total aboveground biomass were not statistically significant ($P > 0.05$). Maximum forage yield for BMR and non-BMR forage sorghum hybrids in 2014, were 15.7 and 18.6 tons/a (65% moisture), respectively. In 2015, the yields were much higher compared to 2014, maximum yield for corn silage, BMR, and non-BMR forage sorghums were 24.6, 17.4, and 21.1 tons/a adjusted to 65% moisture, respectively. These results suggest that with well-watered conditions or full irrigation, corn produced 13% more biomass compared to the non-BMR forage sorghum and 29% more yield compared to BMR forage sorghum.

These results are close to those reported by Bean and Marsalis (2012) for the Texas Panhandle and eastern New Mexico; they reported that corn silage produced 18 to 26% more yield under full irrigation, and BMR forage sorghum yielded 10 to 11% lower compared to non-BMR forage sorghums. It is worth noting that there is a wide range in performance between BMR and non-BMR hybrids; in the Texas Panhandle, BMR hybrids tend to yield 90% of non-BMR varieties (Bean and McCollum, 2006). In this study BMR yielded 85% and 82% of non-BMR in 2014 and 2015, respectively, although it is difficult to make wide generalizations of BMR and non-BMR yield response to water due to hybrid difference; the results from this study suggest that on average non-BMR produce higher yields. For example, observed differences in forage sorghum maximum yield between 2014 and 2015 could be partially attributed to differences in forage sorghum hybrids planted in the two years. High soil pH at Garden City caused iron chlorosis during early growth stages, but the crop was able to overcome it with time and application of foliar iron chelate.

### *Forage Sorghum and Corn Silage Crop Water Use*

During the 2014 growing season, water use ranged between 8 to 11 inches, which is approximately 70% of the average 12 to 16 inches forage sorghum water use reported by Bean and Marsalis (2012) in the Texas High Plains. This observed deviation in seasonal evapotranspiration (ETc) could be attributed to differences in hybrids and climatic conditions between Garden City, KS, and the Texas High Plains. On average, Amarillo, Texas, has higher evapotranspiration compared to Garden City. In 2015, averaged across treatments, crop water use for corn silage, BMR forage sorghum, and non-BMR forage sorghum were 18.4, 17.5, and 19.1 inches, respectively. These results indicate that BMR forage used less water compared to corn silage, but there were no substantial differences in crop water use between corn silage and non-BMR forage sorghum. Figure 3 shows the forage sorghum response to irrigation, with non-BMR responding better than the BMR forage sorghum in 2014. However, there was a flat response to irrigation in 2015 for all crops including corn silage (Figure 4); this is because initial soil water at planting and in-season rainfall provided a substantial portion of crop water requirements. Similar to 2014, non-BMR produced greater biomass compared to BMR forage sorghum. Similar observations have been reported in other studies and variety trials (Bean and McCollum, 2006). However, Bean and Marsalis (2012) noted that this might begin to change as better forage sorghum BMR hybrids are released.

### *Conclusion*

Preliminary results indicate the effect of irrigation capacity on forage yield was significant ($P = 0.0009$) in 2014 but not significant in 2015, probably due to high season rainfall. Corn silage produced significantly ($p < 0.05$) greater biomass at all water levels compared to forage sorghum hybrids in 2015. BMR forage sorghum produced significantly lower total aboveground biomass compared to non-BMR hybrid in 2014 and 2015 ($P < 0.05$). Forage sorghum crop water use ranged between 8 to 11 and 17.5 to 19.1 inches in 2014 and 2015, respectively. In 2015, BMR forage sorghum used less water compared to corn silage, which could be attributed to its lower yield. There was no substantial difference in crop water use between non-BMR forage sorghum and corn silage.

## Acknowledgments

The authors would like to thank the Ogallala Aquifer Program for providing funding. We would also like to express our appreciation to Advanta Seeds US for providing seed for the study. The authors would also like to thank Mr. Dennis Tomsicek and Mr. Jaylen Koehn for implementing the research protocols, data collection, management of irrigation, and other agronomic field operations.

## References

Bean, B.W. (2007). Producing quality forage sorghum silage. Proc. Southern Corn and Rice Minimum Tillage Conference. Houston, TX.

Bean, B.W. and F.T. McCollum. 2006. Forage sorghum vs corn silage. Proceedings Southern Conservation Tillage Conference. Amarillo, TX, June 26-28, pp 113-114. Retrieved Oct. 6, 2007, from http://amarillo.tamu.edu/programs/agronomy

Bean, B. W., and M. Marsalis. 2012. Corn and sorghum silage production Considerations. 2012 High Plains Dairy Conference. Amarillo, Texas. Available at: http://amarillo.tamu.edu/files/2010/11/CornandSorghumSilageProductionConsiderations.pdf.

**Table 1. Forage sorghum yield for the 2014 growing season at the Kansas State University SWREC near Garden City, Kansas. Forage sorghum and corn silage yield under different levels of irrigation in 2014 near Garden City, KS.**

| [1]Irrigation capacity (in/day) | Total irrigation (in) | Forage | Preplant irrigation (in) | At planting irrigation (in) | In-season irrigation (in) | Yield adj. 65% moisture content (tons/a) | Crop value at $26.4/ton ($/ac)[3] |
|---|---|---|---|---|---|---|---|
| Dryland | 3 | [1]BMR | 2 | 0 | 1 | 7 a | 185 |
| | 3 | [2]Non-BMR | 2 | 0 | 1 | 9 b | 238 |
| 0.08 | 6 | BMR | 4 | 0 | 2 | 13 a | 343 |
| | 6 | Non-BMR | 4 | 0 | 2 | 15 b | 396 |
| 0.12 | 7 | BMR | 4 | 0 | 3 | 10 a | 264 |
| | 7 | Non-BMR | 4 | 0 | 3 | 12 b | 317 |
| 0.16 | 6 | BMR | 2 | 0 | 4 | 11 a | 290 |
| | 6 | Non-BMR | 2 | 0 | 4 | 15 b | 396 |
| 0.2 | 7 | BMR | 2 | 0 | 5 | 11 a | 290 |
| | 7 | Non-BMR | 2 | 0 | 5 | 14 b | 370 |
| 0.25 | 7 | BMR | 2 | 0 | 5 | 12 a | 317 |
| | 7 | Non-BMR | 2 | 0 | 5 | 15 b | 396 |

[1]Brown mid rib forage sorghum.

[2]Non-brown mid rib forage sorghum.

[3]Ibendahl, G., D. M. O'Brien, L. Haag, and J. Holman. 2015. Center-Pivot-Irrigated Forage Sorghum Silage Cost-Return Budget in Western Kansas. MF998. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

**Table 2. Forage sorghum yield for the 2015 growing season at the Kansas State University SWREC near Garden City, Kansas. Forage sorghum and corn silage yield under different levels of irrigation in 2014 near Garden City, KS.**

| Irrigation capacity (in/day) | Total irrigation (in) | Forage | Preplant irrigation (in) | At planting irrigation (in) | In-season irrigation (in) | Yield adj. 65% moisture content (tons/a) | Crop value at $26.4/ton ($/ac)[3] |
|---|---|---|---|---|---|---|---|
| Dryland | 2 | [1]BMR | 2 | 0 | 0 | 17 a | 449 |
| | 2 | [2]Non-BMR | 2 | 0 | 0 | 20 b | 528 |
| | 2 | Corn silage | 2 | 0 | 0 | 23 c | 607 |
| 0.08 | 4 | BMR | 2 | 0 | 2 | 15 a | 396 |
| | 4 | Non-BMR | 2 | 0 | 2 | 17 b | 449 |
| | 5 | Corn silage | 2 | 0 | 3 | 21 c | 554 |
| 0.12 | 4 | BMR | 2 | 0 | 2 | 17 a | 449 |
| | 4 | Non-BMR | 2 | 0 | 2 | 21 b | 554 |
| | 5 | Corn silage | 2 | 0 | 3 | 22 c | 581 |
| 0.16 | 5 | BMR | 2 | 0 | 3 | 17 a | 449 |
| | 5 | Non-BMR | 2 | 0 | 3 | 20 b | 528 |
| | 7 | Corn silage | 2 | 0 | 5 | 22 c | 581 |
| 0.2 | 5 | BMR | 2 | 0 | 3 | 17 a | 449 |
| | 5 | Non-BMR | 2 | 0 | 3 | 18 b | 475 |
| | 7 | Corn silage | 2 | 0 | 5 | 23 c | 607 |
| 0.25 | 5 | BMR | 2 | 0 | 3 | 16 a | 422 |
| | 5 | Non-BMR | 2 | 0 | 3 | 19 b | 502 |
| | 7 | Corn silage | 2 | 0 | 5 | 25 c | 660 |

[1]Brown mid rib forage sorghum.

[2]Non-brown mid rib forage sorghum.

[3]Ibendahl, G., D. M. O'Brien, L. Haag, and J. Holman. 2015. Center-Pivot-Irrigated Forage sorghum silage Cost-Return Budget in Western Kansas. MF 998. Kansas State University Agricultural Experiment Station and Cooperative Extension Service.

**Figure 1. Experimental layout of the study on forage sorghum and corn silage response to full and deficit irrigation at the Kansas State University SWREC near Garden City, Kansas.**

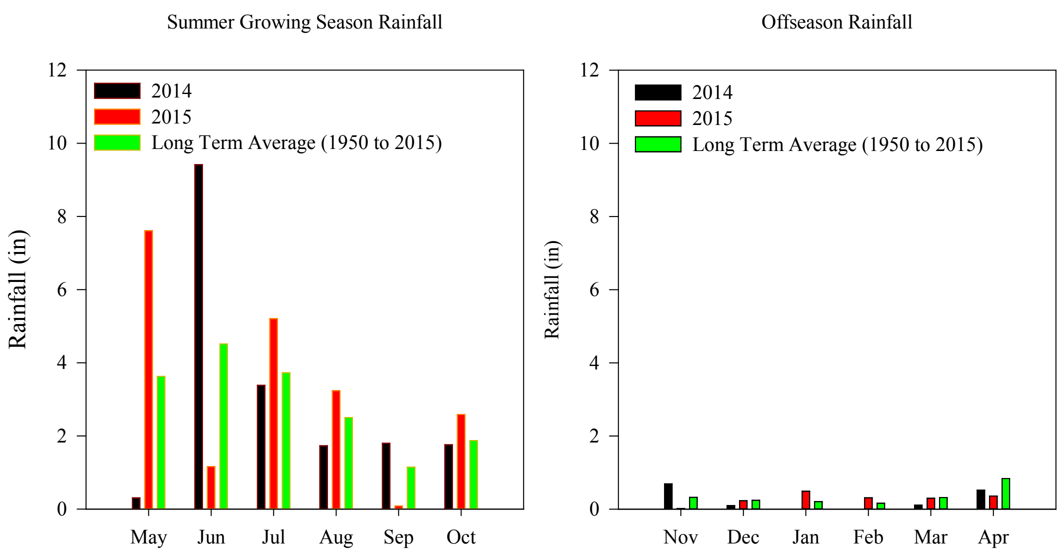


**Figure 2. Growing season (May to October) and offseason rainfall (November to April) for 2014, 2015, and long-term average (1950 to 2015) at the Kansas State University SWREC near Garden City, Kansas.**

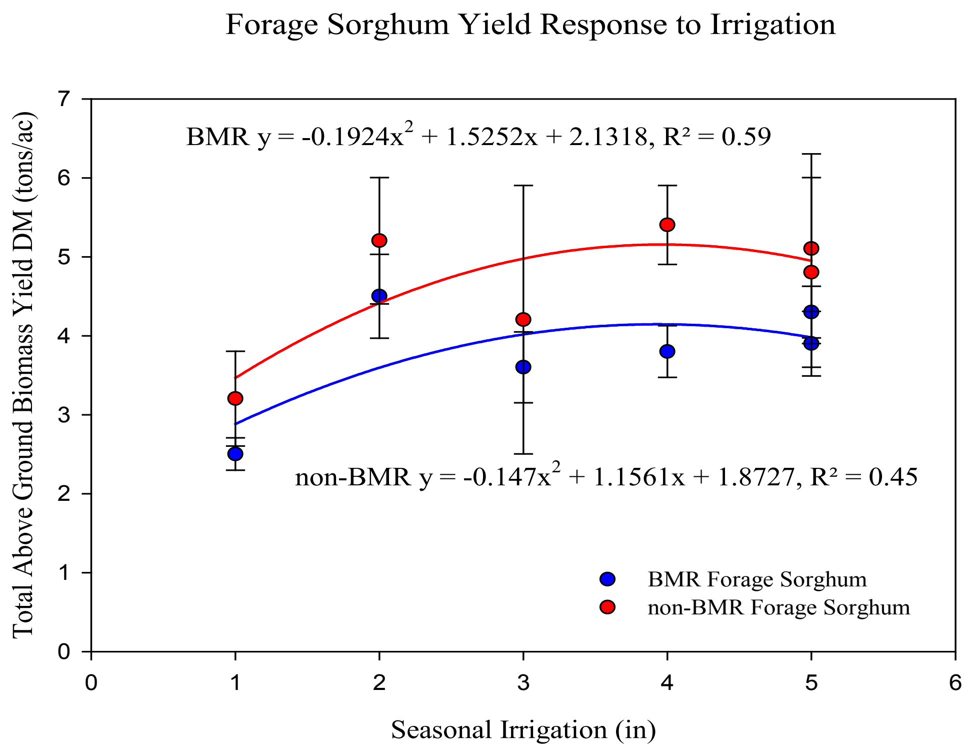


**Figure 3. Response of BMR and non-BMR forage sorghum hybrids to different levels of irrigation during the 2014 growing season at Kansas State University SWREC, near Garden City, Kansas.**

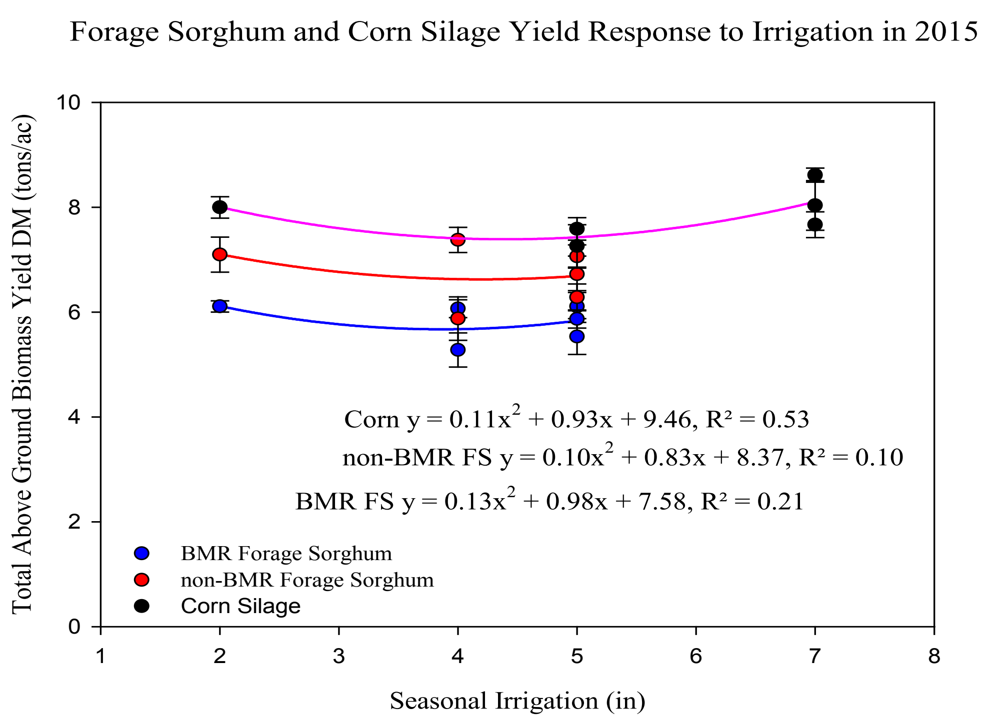


**Figure 4. Response of corn silage, BMR and non-BMR forage sorghum hybrids to different levels of irrigation during the 2015 growing season at Kansas State University SWREC, near Garden City, Kansas.**