# Brown midrib sorghum for lignocellulosic biofuel production

## Introduction

1. Production of ethanol from lignocellulosic biomass contains three major processes viz., Pretreatment, hydrolysis, and fermentation.
2. Pretreatment is required to alter the biomass macroscopic and microscopic size and structure to facilitate rapid and efficient hydrolysis of carbohydrates to fermentable sugars and it is one of the major impediment of converting biomass to bio-fuels as the cost for removal of lignin is high apart from the high cost of enzymes used for saccharification.
3. Genetic manipulation of biomass through introduction of brown midrib *(bmr)* genes conferring low lignin into high biomass sorghums would result in dual-purpose bioenergy sorghums that supply fodder and fermentable sugars from the lignocellulosic biomass.
4. The brown midrib mutants of sorghum have significantly lower levels of lignin content.
5. Purdue university research showed 50 percent higher yield of the fermentable sugars from the stover of certain sorghum bmr lines after enzymatic hydrolysis (Vermerris, 2011). Efforts have been made to develop sorghum breeding lines in brown midrib background for their utility in lignocellulosic biofuel production.

Brown midrib plant

Brown stalks

Brown peduncle

## Objective

To evaluate the *bmr* derivatives for biomass yields and structural carbohydrates

## Material and methods

1. The experimental material consisted of 26 dual-purpose advanced brown midrib progenies including checks.
2. The experiment was laid out in randomized block design with three replications during rainy season of 2015 at Indian Institute of Millets Research, Hyderabad, India.
3. Compositional analysis of stover was done at International Livestock Research Institute located at ICRISAT centre, India

## Results and Discussion

### Biomass characters

- The *bmr* sorghum derivatives (SSV 84 X EC 582508)-2-2 and NP 1 were found promising with a fresh biomass yields of 58 and 57 t/ha and dry biomass yields of 26 and 25 t/ha respectively against the check SPV 2018 which recorded a fresh and dry biomass yield of 22 t/ha and 11 t/ha (Fig 1).
- The same *bmr* derivatives were 156% and 152% superior for fresh biomass and 151 % and 145 % superior for dry biomass over the check.
- The other promising entries for dry biomass yield of 20t/ha and more were (SSV 84 X EC 582508)-1-1, (SSV 84 X IS 21890)-1, EC 582508 X RIO, BN 111 X (CSV 15 x IS 21891)-6-1-2 and (SSV 84 X EC 582508)-2-1.

### Promising entries for biomass yields

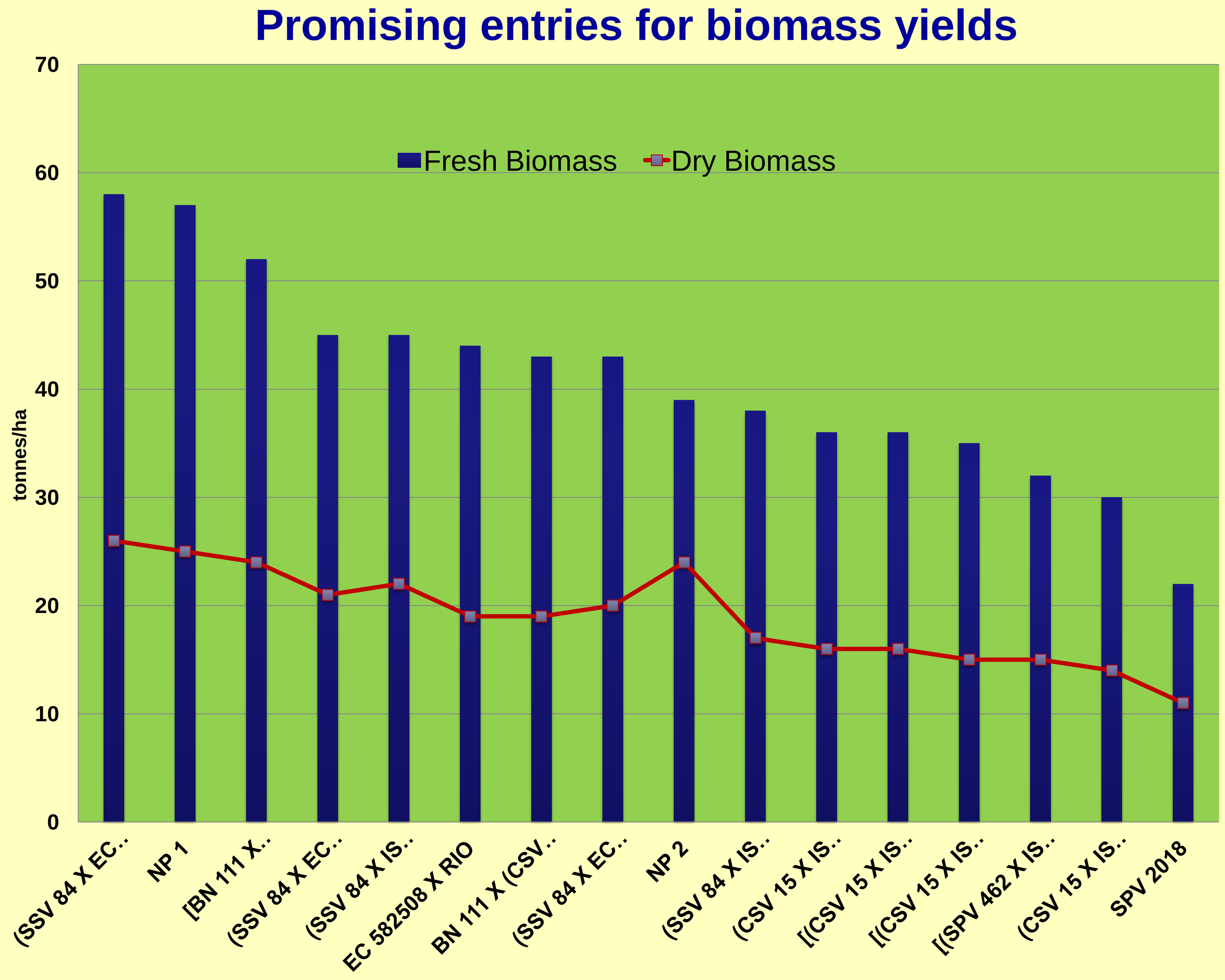


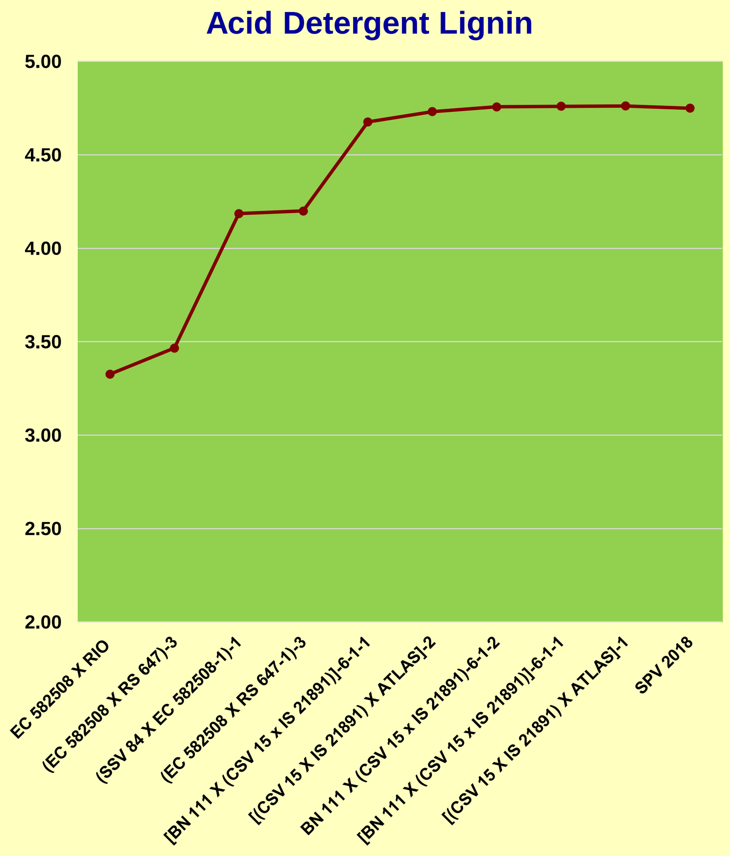

Fig 1. Biomass yields in *bmr* derivatives

### Table 1. Performance of test entries for other characters

| S No | Entry | Plant height (cm) | Stem girth (cm) | Brix (%) |
|---|---|---|---|---|
| 1 | (SSV 84 X EC 582508)-2-2 | 288 | 2.09 | 11.4 |
| 2 | NP 1 | 305 | 2.22 | 17 |
| 3 | [BN 111 X (CSV 15 x IS 21891)]-6-1-1 | 287 | 2.01 | 20.2 |
| 4 | (SSV 84 X EC 582508-1)-1 | 314 | 2.07 | 12.6 |
| 5 | (SSV 84 X IS 21890)-1 | 312 | 2.07 | 17.8 |
| 6 | EC 582508 X RIO | 285 | 1.99 | 15.5 |
| 7 | BN 111 X (CSV 15 x IS 21891)-6-1-2 | 306 | 2.05 | 13.8 |
| 8 | (SSV 84 X EC 582508)-2-1 | 360 | 2.12 | 13.9 |
| 9 | NP 2 | 336 | 2.09 | 16.6 |
| 10 | (SSV 84 X IS 21890)-4 | 349 | 2.02 | 15.2 |
| 11 | (CSV 15 X IS 21891) X ATLAS | 280 | 1.98 | 18.8 |
| 12 | [(CSV 15 X IS 21891-1-1-1) X (HC 260 X B 35)-2-1-1-1 | 282 | 2.01 | 16 |
| 13 | [(CSV 15 X IS 21891) X ATLAS]-2 | 276 | 1.98 | 21.3 |
| 14 | [(SPV 462 X IS 21891-3-1-1) X ROX ORANGE]-1 | 287 | 1.83 | 15.2 |
| 15 | (CSV 15 X IS 21891-1-1-1) X (HC 260 X B 35)-2-1-1-1 | 275 | 1.96 | 17.9 |
| | SPV 2018 © | 259 | 2.22 | 16.9 |
| | C.D. 5% | 38 | 1.9 | 4.5 |

- (SSV 84 X EC 582508)-2-1 was the tallest among the test progenies with a plant height of 360 cm (Table 1) .
- NP 1 and the check SPV 2018 recorded the highest stem girth of 2.22 cm.
- For brix, [(CSV 15 X IS 21891) X ATLAS]-2 (21.3% ) and [BN 111 X (CSV 15 x IS 21891)]-6-1-1 ( 20.2% ) were promising.

### Compositional analysis



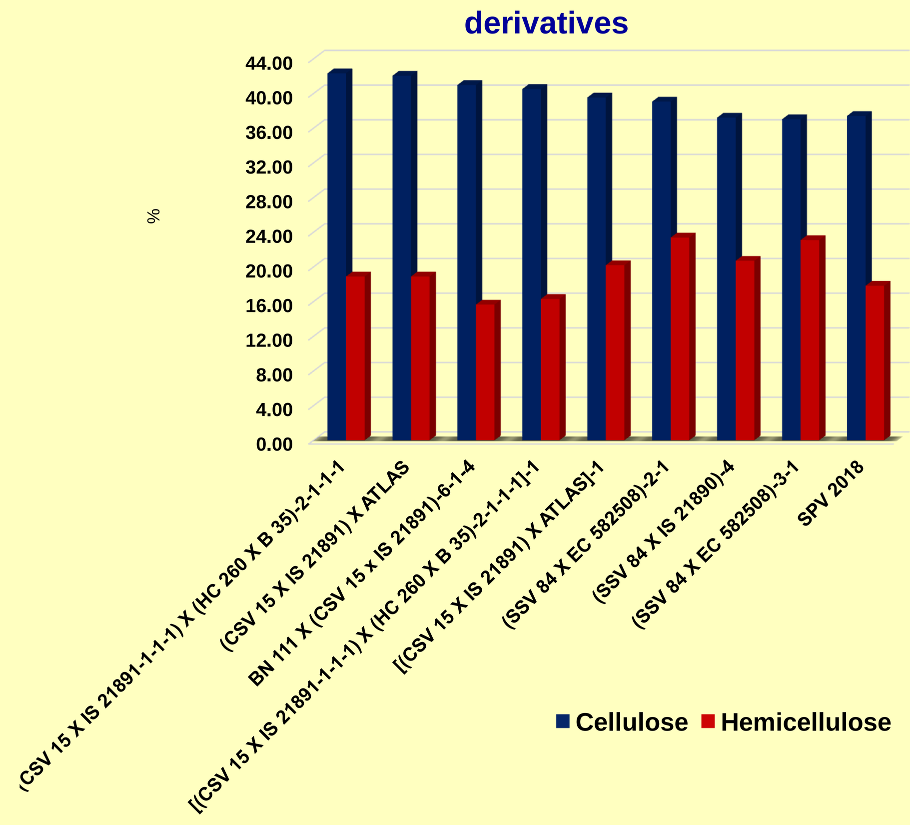




Fig 2. Lignin, Cellulose and Hemicellulose contents in *bmr* derivatives

- (CSV 15 X IS 21891-1-1-1) X (HC 260 X B 35)-2-1-1-1 and (CSV 15 X IS 21891) X ATLAS recorded the highest cellulose content of 42% and had a superiority of 12% over the check SPV 2018 which recorded 37.4% cellulose content (Fig 2).
- EC 582508 X RIO and (EC 582508 X RS 647)-3 recorded the lowest Acid Detergent Lignin (%) of 3% and were superior to the check SPV 2018 (4.7%) by more than 25%
- (SSV 84 X EC 582508-1)-1 and (EC 582508 X RS 647-1)-3 were the other promiosing entries with >10% superiority
- (SSV 84 X EC 582508)-2-1 and (SSV 84 X EC 582508-1)-1 were high in hemicellulose content (23%) against 17% in the check SPV 2018. Superiority was more than 20%.

## Conclusions and future thrusts

- The entries which were promising for low lignin and high biomass were EC 582508 X RIO, (SSV 84 X EC 582508-1)-1 and [BN 111 X (CSV 15 x IS 21891)]-6-1-1 which could be exploited for lignocellulosic biofuel production.
- This type of biomass would greatly reduce the cost of biomass based ethanol production as it is believed that bmr sorghums can play a greater role in lignocellulosic biofuel production due to reduced pre-treatment costs.
- It is worthwhile assessing the potential of *bmr* sorghum in lignocellulosic biofuel production as glucose yields for the brown midrib sorghum biomass were improved by 27%, 23%, and 34% for bmr-6, bmr-12, and the double mutant, respectively, as compared to the wild type, thus reducing lignin content and increasing conversion efficiency of lignocellulose to sugars and ethanol (Dien et al., 2009).

## References


Dien, B.S., Sarath, G., Pedersen, J.F., Sattler, S.E., Chen, H., Funnell-Harris, D.L., Nichols, N.N., Cotta, M.A., 2009. Improved sugar conversion and ethanol yield for forage sorghum (Sorghum bicolor L. Moench) lines with reduced lignin contents. Bioenergy Research 2(3):153- 164. DOI: 10.1007/s12155-009-9041-2.

Vermerris, W., 2011. Survey of genomics approaches to improve bioenergy traits in maize, sorghum, and sugarcane. Journal of Integrative Plant Biology 53, 105–119.



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