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VARIATION IN STRUCTURAL CARBOHYDRATES OF FORAGE SORGHUM [*SORGHUM BICOLOR* (L.) MOENCH] UNDER SALINE CONDITIONS

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SUMMARY

Sorghum, green forage is well adapted to semiarid zones to feed livestock under saline regimes. In present study, structural fibrous fractions were evaluated in two sorghum genotypes *viz*. G-46 and S-713 under different salinity treatments (6, 8 dS/m) to quantify their values. Structural carbohydrate concentrations varied among genotypes and salinity levels. As the salinity level increased, there is reduction of all cell wall components. The cell wall constituents (NDF, ADF, HC, cellulose, lignin) exhibited upward trend with the plant maturity. The NDF content varied from 67.05 to 48.87 % with a relative mean value of 57.96% and at 95 DAS 59.65-76.02 %. Maximum ADF content was observed at maturity stage with a mean value of 40.82%. A significant difference was observed between different growth stages. For total lignin content, the reduction varies from 8.09-6.17 % with a mean value of 5.59 % at 35 DAS. With advancement of maturity, amount of lignin content increased with a mean value of 7.31%. Cellulose and hemicellulose content ranged from 38.09-27.07%, 29.04-24.97 % with mean values of 28.58 and 23.92 %, respectively. Overall, G-46 genotype performed better at all salinity levels and possessed maximum structural fiber fraction and might be a used in future breeding programmes to improve the fiber fractions.

Key words : Sorghum, structural carbohydrates, forage, fodder, cellulose, lignin
Abbreviations : ADF-Acid detergent fibre, NDF- neutral detergent fibre, HC-hemicellulose

In the present world, abiotic stresses became the major constraints in agriculture that adversely affects the crop production worldwide. Salinity became a major worldwide agricultural problem which substantially reduces sustainable crop production (Koji? *et al*., 2012). In arid and semi-arid tropics, salinity is one of the principal limiting factors in crop production primarily due to uneven distribution of rainfall and underground ions (Keshavarz Afshar *et al*., 2014a). To cope with declining crop production under saline regimes, alternative forage crops can be grown (Marsalis and Bean, 2010). Forage crops supply energy and protein to livestock (Eskandari *et al*., 2009). Introduction of new varieties with improved quality and yield are the key determinants in breeding programmes. Crops with high dry matter yield, low fiber, good energy, and better digestibility are some of the important good quality characters (Curran and Posch, 1999). Sorghum (*Sorghum bicolor* L. Moench) is one the most important fodder crop, well adapted in environments with limited rainfall, high temperatures and low soil fertility (Brouk *et al*., 2011, Keshavarz Afshar *et al*., 2014b and Amer *et al*., 2012). Globally, it is a valuable resource for food, feed, biofuel and raw materials for industrial purpose in semi-arid tropics (Fahmy *et al*., 2010). It has higher nutritive value comparable with maize and constitutes major portion of green fodder and later as stover for feeding the livestock (Chakravarthi *et al*., 2017). Sorghum contributes 75% of cultivable area in India mainly in Maharashtra, Karnataka and Andhra Pradesh and globally produces 16% of sorghum production (Singh *et al*., 2018).

Carbohydrates are the major biomolecules present in plant kingdom. Plant growth stage affects the carbohydrate content. In sorghum, the chief structural carbohydrates are lignin and cellulose, and hemicellulose present in the cell wall. Hemicellulose is a highly branched chain polysaccharide, rich in sorghum husk. Sorghum contains both structural and non-structural and carbohydrates. It is also a promising raw material for biofuel production. There is variability in the structural fibrous fractions *viz*. ADF, NDF, ADL among sorghum genotypes which are strongly influenced by interactions among genotype, growth stage and environmental factors (Singh *et al*., 2014). In India, forage crops constitute the major portion of fodder resources due to shortage of concentrate feeds for animals (Datta, 2013). Dry fodder, mainly husk, straw, stover etc. are nutrient deficient and usually fulfill only the appetite of animals. Herbages and green forages are the main sources for ruminants to maintain their moderate levels of production (Das *et al*., 2015). Thus, nutritive evaluation is the only need of hour for their proper growth and optimum utilization in our country. Dietary nutrients such as carbohydrates and proteins are the modified in rumen during digestion (Kamble *et al*., 2011; Singh *et al*., 2012). Determination of feed fractions particularly carbohydrates is key to assess their nutritive value for fodder purpose (Akabari and Parmar, 2014). Knowledge about the influence of salinity on nutritive quality of forage plants is inconsistent and limited. Drought and salinity conditions lead to reduction in ADF and NDF proportion but may improve the dry matter digestibility and crude protein (Jahanzad *et al*., 2013; Newman, 2014). Thus, the present study was undertaken to determine the effect of salinity on cell wall components of sorghum genotypes under normal and saline conditions.

MATERIALS AND METHODS

The present study was conducted at Department of Biochemistry and Department of Animal Sciences, CCS HAU, Hisar. Two sorghum genotypes *viz*. G-46 and S-713 were grown in net house conditions under different salinity levels (6, 8 dS/m) during *kharif* season 2017-18 and analyzed for structural carbohydrates viz. ADF, NDF, cellulose, hemicellulose, lignin and silica. Sampling was done at pre-flowering (35 DAS) and post flowering stage (95 DAS). Fresh fodder samples were kept dried in hot air oven at 100°C for 72 hours to constant weight. Dried samples were then ground in Willey mill using 2mm screen. The ground samples were then stored in brown papers until analysis. The analysis was done in triplicates and expressed on dry weight basis. Acid detergent fiber (ADF) and neutral detergent fiber (NDF) were determined by the method of Van Soest *et al*. (1991). Lignin was determined by dissolving cellulose with 72% (w/w) H_2SO_4 in the ADF residue. Cellulose content was estimated by the difference between ADF and lignin in the sequential analysis of the samples. The difference between NDF and ADF gave indirect measure of hemicellulose (HC). The experimental data were analyzed using analysis of variance for the complete randomized design (CRD) where each observation was replicated thrice. To compare the treatments, critical difference (P= 0.05) was calculated.

STATISTICAL ANALYSIS

The experimental data were analyzed using analysis of variance for the complete randomized design (CRD) where each observation was replicated thrice. To compare the treatments, critical difference (P= 0.05) was calculated.

RESULTS AND DISCUSSION

Carbohydrates are the major source of energy in plants. They are the primary source of animal nutrition for microflora present in rumen of animals (Van Soest, 1994). Composition of carbohydrates is largely influenced by various factors such as growth stage, variety, and the environmental conditions during growth. Forage quality is determined by the presence of low concentration of fibre in the fodder as higher level adversely affects its nutritional value. Higher is the fibre content, lower is the digestibility and vice-versa (Karthikeyan *et al*. (2017). With maturity of the plant, fibre portion increases. In present study, NDF content varied from 67.05 to 48.87 % with a mean value of 57.96 % (Table 1). NDF was highest in G-46 (57.74 %) and lowest in S-713 (48.87 %) at 8 dS/m at 35 DAS. While at maturity stage, NDF content increased ranged from 59.65-76.02 % (Table 2). Maximum NDF was found in G-46 (76.02 %). Increase in salinity levels reduces the NDF content significantly. Higher NDF content leads to poor intake rates. Singh *et al*. (2003); Carmi *et al*. (2005), Colombo *et al*. (2007), Singh and Shukla (2010) and Chakravarthi *et al*. 2017; Singh *et al*. (2018) supported the results. Carvalho *et al*. (2007) reported that NDF fraction influences the carbohydrate fraction in sorghum. Variability in carbohydrates fractions might be due to variations in leaf area index, soil texture, stage of maturity, and climatic conditions. High NDF content might be due to higher level of slowly degradable cell wall, affecting the growth of microbes in rumen and animal performance (Ribeiro *et al*., 2001). Significant difference was observed among structural components.

Table 1 depicts the ADF content in sorghum

TABLE 1

Variation in structural carbohydrates in sorghum genotypes at different salinity levels during vegetative stage

		35 Days after Sowing (DAS)					
		NDF	ADF	Hemicellulose	Cellulose	Lignin	Silica
Control	G-46	67.05±0.221	40.69±0.277	26.79±0.153	33.37±0.113	6.88±0.047	1.75±0.012
	S-713	58.86±0.512	34.78±0.309	25.36±0.087	28.64±0.25	5.28±0.047	1.60±0.007
6 dSm-1	G-46	62.36±0.548	37.27±0.214	25.35±0.221	31.06±0.273	5.99±0.035	1.62±0.015
	S-713	52.89±0.356	30.23±0.173	22.15±0.15	25.83±0.173	4.82±0.029	1.44±0.01
8 dSm-1	G-46	57.74±0.332	34.65±0.202	23.98±0.215	28.58±0.164	5.78±0.035	1.34±0.012
	S-713	48.87±0.286	28.97±0.197	19.90±0.113	24.01±0.141	4.79±0.033	1.27±0.009
CD at 5%		(A) 0.708	(B) 0.867		(AxB) N/A		

genotypes at vegetative stage. Lower the ADF content, higher the feed digestibility (i.e., of superior quality) and lower NDF content contributes to higher intakes (Karthikeyan *et al*., 2017). This indicates that when structural fibre content is high, digestibility, nutrient value, and palatability will be low which ultimately results in poor forage quality (John, 2005). The mean ADF value observed in this study was 34.43 % with a range of 28.97-40.69 %. As compared with control, highest value of ADF was found in G-46 (34.65 %) and lowest in S 713 (28.97 %) at 8dS/m as compared with control (G-46- 40.69 %, S-713-34.78 %). Maximum ADF content was observed at maturity stage with a mean value of 40.82 %. G-46 had maximum fractions (40.31) and S-713 had minimum value (33.42) at 8dS/m (Table 2). These results are in agreement with Singh *et al*. (2003); Colombo *et al*. (2007); Marsalis *et al*. (2010); Barba *et al*. (2012) and Matos *et al*. (2014). For total lignin content, the reduction varies from 8.09-6.17 % with a mean value of 5.59 % at 35 DAS (Table 1). Maximum and minimum reduction at highest level of salinity was found in G-46 (7.01 %) and S 713 (6.17 %) During maturity, amount of lignin content increased with a mean value of 7.31 % (Table 2). Compared with control, lignin content decreased as salinity level increased. A significant difference was observed between different growth stages. Chakravarthi *et al*. (2017) studied the nutritive value of forage sorghum and supported the results and stated that sorghum was nutritionally superior fodder for animal feed in drought prone areas. Karthikeyan *et al*. (2017) evaluated 24 sorghum accessions for nutritional quality and fodder yield potential and reported that the genotype TKSV 1126 had the best digestibility and nutrient value and might be utilized in back crossing programme.

The presence of higher portion of fibre portion *viz*. hemicellulose, cellulose, lignin and silica in the fodder will seriously affect the digestibility process. Cellulose and hemicellulose content ranged from 38.09-27.07 % and 29.04-24.97 % with mean values of 28.58 and 23.92 %, respectively (Table 1). A significant difference was observed at both vegetative and maturity stage in both genotypes. As plant grows, its biomass increased, resulting in higher values. At maturity stage, the genotypes G-46 had maximum cellulose and hemicellulose content while minimum was observed in S-713 (Table 2). These observations are in resemblance with those reported by Singh *et al*. (2003) who observed that mean value of cellulose content was 35.40 per cent. Lower values of hemicellulose might be attributed to high proportion

TABLE 2

Variation in structural carbohydrates in sorghum genotypes at different salinity levels during maturity stage

		95 Days after Sowing (DAS)					
		NDF	ADF	Hemicellulose	Cellulose	Lignin	Silica
Control	G-46	76.02±0.253	47.50±0.32	29.04±0.167	38.90±0.13	8.09±0.053	2.10±0.012
	S-713	66.50±0.578	42.85±0.382	25.17±0.083	33.88±0.297	7.94±0.074	1.66±0.007
6 dSm-1	G-46	68.58±0.6	42.69±0.245	26.20±0.229	34.93±0.305	7.50±0.043	2.05±0.018
	S-713	61.95±0.417	38.16±0.219	23.15±0.157	31.52±0.213	7.16±0.04	1.46±0.01
8 dSm-1	G-46	64.31±0.37	40.31±0.234	24.97±0.224	32.97±0.19	7.01±0.04	1.89±0.018
	S-713	59.65±0.349	33.42±0.223	26.18±0.15	27.07±0.159	6.17±0.04	1.22±0.006
CD at 5%		(B) 0.801	(B) 0.982		(AxB) 1.338		

of ADF (Chakravarthi *et al*., 2017). Silica content ranged from 1.75-1.27 % with a mean value of 1.50 %. While at maturity, mean value was 1.73 % among different salinity levels. G-46 had maximum silica at both 35 and 95 DAS (1.34 and 1.89 %), respectively. Overall, G-46 genotype performed better at all salinity levels and possessed maximum structural fiber fraction. Firdous and Gilani (2001) and Zahid *et al*. (2014) reported the similar results in sorghum cultivars at mature stage. The composition of detergent fibers analysis is consistent with that study of Dien *et al*. (2009).

CONCLUSION

Evaluation of sorghum genotypes (G-46 and S-713) reveled that these genotypes are a good source of structural carbohydrates which may be utilized as a potential green fodder crop for livestock management in saline areas.

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