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C o n t e n t s

Executive summary

Twelve kharif sorghum cultivars (6 hybrids + 6 verities) released during during last four decades were assessed for physiological basis of genetic gains in the yield potential. Significant differences ($P \leq 0.05$) were observed among the genotypes for phenology (days 50% flowering and physiological maturity) within each location as well as between the averages across locations. In phenology (days to 50 % flowering and physiological maturity), genotypes, CSH 14 and CSH 27 were the earliest in flowering as well as in maturity. The genotypes like CSV 23, CSH 14, CSV 20, CSV 27and CSV 25 were the top genotypes were the top grain yield while CSV 27, CSV 25 and CSV 20 were the top in total biomass accumulation. The genotypes CSH 14, CSH 15, CSV 23, CSH 25 and CSV 27 maintains higher LA and LAI at flowering as compared to other genotypes. SLA was lowest (thicker leaves) in CSV 27 followed by CSV 15, CSV 23, CSH 30 and CSV 27. CSV 23 and CSV 27 were found have best desirables physiological traits like RWC, SPAD values, chlorophyll content, CSI and MSI among the 12 cultivars evaluated .

Sixteen kharif sorghum parental lines (8- B lines + 8- R lines) were assessed for phenolgy, yield components and physiological characteristics. Significant differences ($P \leq 0.05$) were observed among the genotypes for phenology (days 50% flowering and physiological maturity) within each location as well as between the averages across locations. Among the B lines, AKMS 14B was the top grain yielder followed by 296B and MS7B, while among R lines CB33 produced highest grain yield followed by CS3541 and C43. At maturity the biomass accumulation was maximum in 279B followed by AKMS 14B and 415B among B lines and CB11 followed by CB33 and RS29 among R lines. CB11 was among the three top entries among R lines for panicle weight, grain number per panicle and 1000 grain weight. Genetic variations among 16 parental lines for averages across locations of important agronomical parameter like leaf area, leaf area index and specific leaf area were non-significant. The variations among the physiological parameters like relative water content, SPAD values, chlorophyll content, chlorophyll stability index and membrane stability index, although recorded in one location only, were highly significant among the genotypes, but different genotypes have improved adaptation different physiological traits.

This experiment was conducted successfully at two location only i.e. Hisar and Bapatla. As trial at Bapatla was conducted during rabi and data was not available at the time of reporting, therefore, we are presenting the results from one location i.e. Hisar. At this location the trial was conducted at three level of salinity (Non-saline, 8 dS/m and 10 dS/m). Fifteen genotypes + three checks were sown at three levels, but most of genotypes collapsed under highest levels of salinity after few days of seedling growth. Only three genotypes (SPH 2457, SPH 2462 and CSV 24SS) survived and accumulated substantial biomass at maturity. Only one genotypes (SPV 2457) could produced some grain yield. We analysed the data of 14 genotypes (12 entries + 2 checks) under two treatments (Non-saline, 8 dS/m), since four genotypes (SPV 1825, 1858 2324 and CSV 22SS) collapsed even under 8 dS/m.

Among the fourteen genotypes evaluated under salinity at Hisar, the genotypes SPV 2462, SPV 2457 and CSV 19SS accumulated the highest quantity of both fresh and dry biomass under salinity at maturity. Out of fourteen genotypes evaluated under salinity, only five genotypes produced grain yield and it was highest in SPV 2457 followed by SPV 1861. In physiological parameters, a reduction of more than 10%, 31% and 15% in RWC, Chlorophyll content and SPAD values, respectively were recorded under salinity as compared to non-saline treatment. SPV 1862, SPV 2462, SPV 2457 and SPV 1798 Maintains the highest values under salinity. Most of the genotypes accumulates the Na+ under, whereas there is reduction in K and Ca contents. Average ionic content in the leaves across genotypes indicates accumulation of Na ion is increased by 7%, but the accumulation of K and Ca ions decreased by 20% and 2% , respectively. Although the trend of relationships of biomass accumulation in fourteen genotypes evaluated was negative with Na ion content and positive with K and Ca ions content, respectively, but these relationship was non-significant. The best relationship was between biomass accumulation under two treatments and K contents (R2 = 0.232). But the relationship of the ration of K+/Na+ in leaves, although poor but was significant (R2 = 0.372) with biomass accumulation under two treatments (Figure 1d). This indicates that ionic ratio of K+/Na+ can be potential selection criteria for salinity tolerance in sorghum.

Detailed report

The primary objectives of kharif physiology were:

- To quantify changes in yield components associated with grain yield progress in sorghum historical released cultivars (hybrids& varieties) and parental lines (B and R-lines).
- To identify putative physiological traits associated with yield increase and to investigate physiological causes of variation in yield between old and new sorghum cultivars and s parental lines (B and R-lines)..
- To identify potential donors with salinity tolerance and identify morpho-physiological traits associated with salinity tolerance

Three trials were panned for Kharif 2016. Two trials (1K and 2K)were conducted three locations i.e. Parbhani (19^0 08' N; 76^0 50'E), Phaltan (18^0 47' N; 74^0 32'E), and Akola (21° N; 77° E). The third trial (3K) was a pot experiment conducted at Hisar.

1. Trail 1K: Physiological basis of assessing the genetic progress in yield potential of kharif sorghum historical released cultivars
2. Trial 2K: Physiological characterization of kharif parental lines (old and new) for yield potential released during last four decades
3. Trial 3K: Evaluation of sorghum elite lines (forage/sweet sorghum) for salinity tolerance

Trial 1K. Physiological basis of assessing the genetic progress in yield potential of kharif sorghum historical released cultivars

Twelve kharif sorghum released cultivars (6 hybrids + 6 verities) were assessed for physiological basis of genetic gains in the yield potential. Each genotype was planted in four rows of 5m length (plot size: 1.8 * 5.0m =9.00 m2) in RCB design with three replications. The crops were raised entirely on rainfed condition and were allowed to grow under natural rainfall conditions. The soil was light to medium vertisol. A plant spacing of 45 cm between the rows and 15 cm within the row were adopted.

Recommended dose of fertilizer was applied (@ 60:30:0 kg N: P2O5: K2O ha^{-1} in the form of urea, single super phosphate, muriate of potash, respectively) with half N and complete P and K as basal, and balance N was side-dressed at 35 DAE. Furadan 3G (@ 20 kg ha^{-1}) was applied in furrows at planting to control the shoot fly (*Atherigona soccata* R). Need based minimal plant protection measures were followed to control the major insect pests of sorghum. The data were collected as per standard procedures and are presented in tables 1K1.1 to IK1.4.

Phenology: Significant differences ($P \leq 0.05$) were observed among the genotypes for phenology (days 50% flowering and physiological maturity) within each location as well as between the averages across locations (Table 1K1.1).. On the other hand, plant height varies significantly within each location, but the variations among the average heights of genotypes across location was non-significant. The overall average plant stand across locations was 11.1 plants/m^2 which varied non-significantly among the genotypes (Table 1K1.1). This indicates that overall 75% of the recommended plant stand was maintained which was satisfactory. In phenology (days to 50 % flowering and physiological maturity), genotypes, CSH 14 and CSH 27 were the earliest in flowering as well as in maturity. The flowering ranged from 64 to 72 days with an average of 68 d. The average days to flowering was lowest at Akola (64) followed by Phaltan (68 d) and Parbhani (72 d). Almost similar trend was observed in days to maturity too (Table 1K1.1). In plant height and average of 176 cm was recorded across locations with a range of 129 to 207 cm. The plant height was maximum at Parbhani (207 cm) followed by Phaltan (191) and Akola (129). CSV 27, CSH 13K & R, CSV 23 and SPV 462 were taller than other genotypes.

Yield components: Grain yield, total biomass both at flowering and physiological maturity and stover yield differed significantly $P \leq 0.05$) at all locations (Table 1K 1.2). Although variations in the average grain yield and stover yields across locations were non-significant, but variations in the average total biomass both at flowering and physiological maturity across were highly significant. Highest location mean values for grain yield were recorded at Parbhani followed by Akola. On the other hand Highest location mean values of biomass both at flowering and physiological maturity and stover yield was recorded at Akola. The genotypes like CSV 23, CSH 14, CSV 20, CSV 27and CSV 25 were the top genotypes were the top grain yield while CSV 27, CSV 25 and CSV 20 were the top in total biomass accumulation (Table 1K 1.2).The other yield components like panicle dry weight, harvest index, grain umber/panicle and 1000 grain weight also differ significantly at all the three location, however average means across locations of these parameters varies significantly only for harvest index and grain umber/panicle, while it was non-significant for panicle dry weight and harvest index. CSV 23 and CSV 27 were the top genotypes for most of these yield components (Table 1K 1.3)

Physiological components: Leaf mass at flowering (LDF), leaf area at flowering (LA), leaf area index (LAI) at flowering, specific leaf area (SLA), Relative water content (RWC), SPAD values, chlorophyll content, chlorophyll stability index (CSI), membrane stability index (MSI) varies significantly between genotypes within each locations (Table 1K 1.3 and 1.4). On the other hand variation average of LDF, LA, LAI and SLA across location were non-significant. The genotypes CSH 14, CSH 15, CSV 23, CSH 25 and CSV 27 maintains higher LA and LAI at flowering as compared to other genotypes. SLA was lowest (thicker leaves) in CSV 27 followed by CSV 15, CSV 23, CSH 30 and CSV 27. Data on the other physiological parameters like RWC, SPAD values, Chlorophyll content, CSI and MSI were recorded only in one location but mostly CSV 23 and CSV 27 were maintaining the top ranking (Table 1K 1.4).

Trial 2K. Physiological characterization of kharif parental lines (old and new) for yield potential released during last four decades

Sixteen kharif sorghum parental lines (8- B lines + 8- R lines) were assessed for phenolgy, yield components and physiological characteristics. Each genotype was planted in four rows of 5m length (plot size: 1.8 * 5.0m =9.00 m2) in RCB design with three replications. The crops were raised entirely on rainfed condition and were allowed to grow under natural rainfall conditions. The soil was light to medium vertisol. A plant spacing of 45 cm between the rows and 15 cm within the row were adopted.

Recommended dose of fertilizer was applied (@ 60:30:0 kg N: P2O5: K2O ha^{-1} in the form of urea, single super phosphate, muriate of potash, respectively) with half N and complete P and K as basal, and balance N was side-dressed at 35 DAE. Furadan 3G (@ 20 kg ha^{-1}) was applied in furrows at planting to control the shoot fly (*Atherigona soccata* R). Need based minimal plant protection measures were followed to control the major insect pests of sorghum. The data were collected as per standard procedures and are presented in tables 2K1.1 to 2K1.4.

Phenology: Significant differences ($P \leq 0.05$) were observed among the genotypes for phenology (days 50% flowering and physiological maturity) within each location as well as between the averages across locations (Table 2K1.1).. On the other hand, plant height varies significantly within each location, but the variations among the average heights of genotypes across location was non-significant. The overall average plant stand across locations was 10.9 plants/m^2 which varied non-significantly among the genotypes (Table 2K1.1). This indicates that overall 75% of the recommended plant stand was maintained which was satisfactory. In phenology (days to 50 % flowering and physiological maturity), PMS28B was the earliest followed by RS29 and AKR150 in flowering as well as in maturity. The flowering ranged from 65 to 75 days with an average of 70 d. The average days to flowering was lowest at Akola (65) followed by Phaltan (69 d) and Parbhani (75 d). Almost similar trend was observed in days to maturity too (Table 2K1.1). In plant height and average of 135 cm was recorded across locations with a range of 117 to 150 cm. The plant height was maximum at Parbhani (150 cm) followed by Phaltan (139) and Akola (117). CB33 was the tallest followed by RS29, CB11 and RS627 (Table 2K1.1).

Yield components: Grain yield, total biomass both at flowering and physiological maturity and stover yield differed significantly $P \leq 0.05$) at all locations (Table 2K 1.2). Although variations in the average grain yield and average total biomass both at flowering and physiological maturity and across locations were highly significant, but variations in the average stover yields across locations were non- significant. Highest location mean values for grain yield were recorded at Akola followed by Parbhani and Phaltan. Similarly highest location mean values of biomass both at flowering and physiological maturity and stover yield was also recorded at Akola. Among the B lines, AKMS 14B was the top grain yielder followed by 296B and MS7B, while among R lines CB33 produced highest grain yield followed by CS3541 and C43. In biomass production at flowering 2219B was the topper followed by PMS28B and 415B among the eight B-lines and CB33 followed by RS627 and CB11 were the topper among R lines (Table 2K 1.2). At maturity the biomass accumulation was maximum in 279B followed by AKMS 14B and 415B among B lines and CB11 followed by CB33 and RS29 among R lines (Table 2K 1.2). The trend of stover production was almost similar to that biomass accumulation at maturity among the R lines, while it is PMS28B which produced highest stover yield followed by 415M and 2219B among the B-lines The other yield components like panicle dry weight, harvest index, grain umber/panicle and 1000 grain weight also differ significantly at all the three location. Although the average means across locations of Panicle dry weight, harvest index and grain number per panicle also varied significantly, but variations in the average mean across location of 1000 grain weight were nono-significant. CB11 was among the three top entries among R lines for panicle weight, grain number per panicle and 1000 grain weight (Table 2K 1.3)

Physiological components: Leaf mass at flowering (LDF), leaf area at flowering (LA), leaf area index (LAI) at flowering, specific leaf area (SLA), Relative water content (RWC), SPAD values, chlorophyll content, chlorophyll stability index (CSI), membrane stability index (MSI) varies significantly between genotypes within each locations (Table 2K 1.3 and 1.4). On the other hand variation in average across location of LA, LAI and SLA were non-significant. The variations among the physiological parameters like relative water content, SPAD values, chlorophyll content, chlorophyll stability index and membrane stability index, although recorded in one location only, were highly significant among the genotypes, but different genotypes have improved adaptation different physiological traits.

Trial 3K. Evaluation of sorghum elite lines (forage/sweet sorghum) for salinity tolerance

Pots experiments were planned to evaluate the selected set of elite lines of forage/sweet sorghum for salinity tolerance at three locations- Hisar, Bapatla and Gangawati. We could not executed the trial at Gangawati, as we could not get the naturally salinised plots, hence it was decided to conduct during 2017. The trial at Bapatla was conducted during rabi season, we yet to receive the data from this location. Therefore, we are presenting the results from one location 1.e Hisar. At this location the trial was conducted at three level of salinity (Non-saline, 8 dS/m and 10 dS/m). Fifteen genotypes + three checks were sown at three levels, but most of genotypes collapsed under highest levels of salinity after few days of seedling growth. Only three genotypes (SPH 2457, SPH 2462 and CSV 24SS) survived and accumulated substantial biomass at maturity. Only one genotypes (SPV 2457) could produced some grain yield. We analysed the data of 14 genotypes (12 entries + 2 checks) under two treatments (Non-saline, 8 dS/m), since four genotypes (SPV 1825, 1858 2324 and CSV 22SS) collapsed even under 8 dS/m. The data are presented in tables 3K1.1.

Phenology: Data on these 14 genotypes indicated that means of 'days to flowering' did not varied significantly between two treatments i.e. Non-saline and 8 dS/m. But genotypes differed significantly to DAF within each treatment. CSV 19SS, CSV 22SS, SPV 2459 and SPH 1798 were the earliest, while SPH 1859, SPV 2458 and SPV 2462 were the latest in flowering under salinity.

Growth parameters at flowering: The average plant height and number of leaves at flowering stage were reduced significantly under salinity as compared with non-saline. On average the plant height was reduced by more than 45% under salinity as compared with non-saline treatment. SPV 2462 was the tallest followed by CSV 19SS and SPV 2456. Similarly, on an average the number of leaves , leaf area, fresh biomass and dry weight per plant at flowering were reduced by more than 32%, 64%, 88% and 80% respectively under salinity as compared that of non saline treatment. The genotypes SPV 1798 maintains highest values under salinity stress among the genotypes evaluated. The other promising genotypes were SPV 2457, SPV 1862, SPV 2462 and SPV 1859.

Growth and yield parameters at Maturity: The average plant height and number of leaves at maturity were reduced significantly under salinity as compared with non-saline. On average the plant height was reduced by more than 46% under salinity as compared with non-saline treatment. SPV 2462 was the tallest followed by CSV 19SS and SPV 2459. Similarly, on an average the number of leaves , fresh weight, dry weight and grain yield per plant at maturity were reduced by more than 37%, 67%, 68% and 61% respectively under salinity as compared that of non saline treatment. The genotypes SPV 2462, SPV 2457 and CSV 19SS accumulated the highest quantity of both fresh and dry biomass under salinity at maturity. Out of fourteen genotypes evaluated under salinity, only five genotypes produced grain yield and it was highest in SPV 2457 followed by SPV 1861.

Physiological parameters at flowering: Three parameters, Relative water content (RWC), chlorophyll content and SPAD values were recorded in all the fourteen genotypes under both non-saline and saline treatments. On an average, a reduction of more than 10%, 31% and 15% in RWC, Chlorophyll content and SPAD values, respectively were recorded under salinity as compared to non-saline treatment. SPV 1862, SPV 2462, SPV 2457 and SPV 1798 Maintains the highest values under salinity.

Ionic contents: Most of the genotypes accumulates the Na+ under, whereas there is reduction in K and Ca contents. Average ionic content in the leaves across genotypes indicates accumulation of Na ion is increased by 7%, but the accumulation of K and Ca ions decreased by 20% and 2% , respectively. The maximum Na ions were accumulated under salinity in SPV 2451 followed by 2456 and 1861, whereas minimum were accumulated in SPV 1862 followed by 1859 and 2460. The K ions accumulation was accumulated in SPV 1798 followed by 2456 and CSV 19SS, whereas was accumulation of K ions were minimum in SPV 2460 followed by 1860 and 1861.

Relationship between biomass accumulation and Ionic content: Although the trend of relationships of biomass accumulation in fourteen genotypes evaluated was negative with Na^+ ion content and positive with K^+ and Ca^{2+} ions content, respectively, but these relationship was non-significant (Figure 1 a, b & c). The best relationship was between biomass accumulation under two treatments and K^+ contents (R^2 = 0.232). But the relationship of the ratio of K^+/Na^+ ions in leaves with biomass accumulation under two treatments (Figure 1d), although was poor, but significant (R^2 = 0.372). This indicates that ionic ratio of K^+/Na^+ can be potential selection criteria.

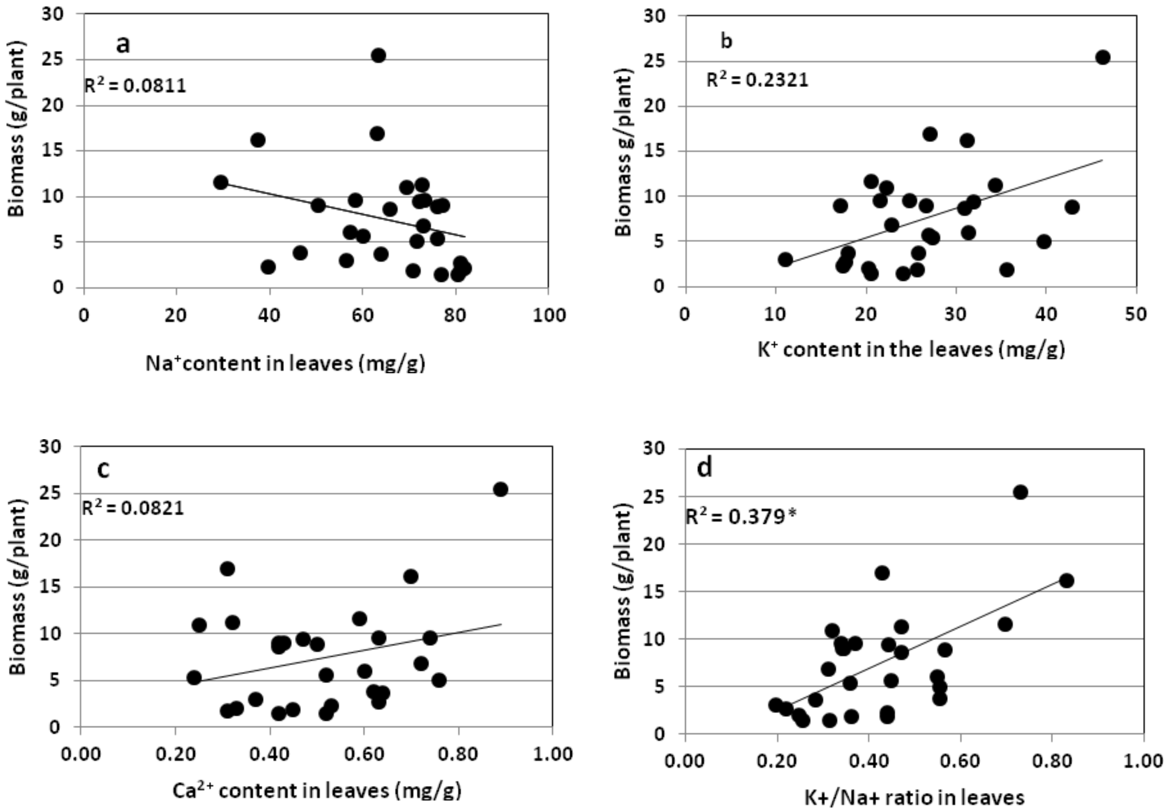

Figure 1. Relationships between biomass accumulation at flowering with different ionic contents in leaves, a) Na^+ , b) K^+ , c) Ca^{2+} and d) ratio of K^+/Na^+