Sorghum Physiology - Rabi 2016-17

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Content

Executive summary

Trial 1R: Preliminary evaluation of diverse germplasm for rabi adaptation: Thirty-seven rabi sorghum landrace germplasm along with three checks were evaluated at Tandur, Bijapur, Solapur, Rahuri Parbhani and Gulbarga. Six entries flowered at least 2 days earlier than check CSV 22R (77) include RSV 1542, RSV 1749, RSV 1767, RSV 1850, SSRK 13-1 and SSRK 13-2 (72-75). Plant height differed significantly ($P \leq 0.05$) at different locations and ranged from 133 to 219 cm with an average of 183 cm . Leaf are index (LAI) at flowering varied significantly ($P \leq 0.05$) at different locations and ranged from 1.48 (Bijapur) to 3.32 (Rahuri) with a mean of 2.22. Although the variation across the entries dies not differ significantly, but it varies from 1.83 to 2.71 with highest in SSRK 13-1 (2.7) followed by RSV 1516 (2.64) and SLV 184 (2.58). Entries maintained higher SPAD include SSRK 13-15, RSV1850, SSRK 13-11 and RSV 1516 (55-56) than check CSV 22R. Genotypes produced significantly superior biomass yields than check CSV 22R includes SSRK 13-17, RSV 1516, SSRK 13-15, SSRK 13-4 and RSV 1785. Exceptionally high grain yields were obtained at Rahuri hence it was included in the analysis. Among the other five locations (Bijapur, Parbhani, Solapur, Gulbarga and Tandur) the average grain yield varied between 2077 to 2977 kg/ha. Genotypes with highest 1000 seed weight includes SLV 183 (39.4 g) followed by RSV 1542 (38.7 g) and SLV 181 (38.2 g), respectively. Genotypes with highest HI includes SSRK 13-2 (33.2%) followed by BJV 129 (32.1%) and BJV 362 (31.8%), respectively.

Trial 2(M) & 3(S): Phenotyping advanced rabi sorghum entries for drought adaptation traits in medium and shallow soils: Sixteen advanced rabi-adapted sorghum genotypes were phenotyped in both medium and shallow soils Bijapur, Parbhani, Rahuri, Solapur and Tandur. Significant difference ($P \leq 0.05$) was observed in plant height in both the soil depths at all the locations. Plant height ranged from 151 to 218 cm in medium and 141 to 165 cm in shallow soils. Average plant height decreased by 16.2 % in shallow soil over medium. Leaf area index (LAI) varied significantly ($P \leq 0.05$) at all locations in both soils depth. Mean LAI decreased by 33.0 % in shallow soil over medium. The minimum decreased in LAI in shallow soil as compared that in medium soil was observed in BJV 348 followed by

BJV 129 and BRJ 204. Average biomass production of two locations (Rahuri and Bijapur) at flowering decreased by 19.5 % in shallow soil over medium. The reduction biomass was more at Rahuri (45.2%) than Bijapur (10.2%). The minimum decreased in biomass accumulation in shallow soil as compared that in medium soil was observed in Phule suchitra followed by CRS 49 and BJV 125. Relative leaf water content (RLWC) recorded at flowering significantly ($P \leq 0.05$) varied at both Bijapur and Rahuri locations. RLWC at flowering reduced by 3.9% in shallow soil stress conditions over medium. Almost all the genotypes maintained higher RLWC as compared to check *Phule Anuradha* in both the soils. RSV 1640 maintained highest RLWC in both type of soil, hence more stable in maintaining the crop water status .Grain yield, dry fodder yield, HI and 1000-seed mass differed significantly ($P \leq 0.05$) at all locations in both soil depths. Mean grain yield ranged from 2220 to 2965 kg ha^{-1} and 809 to 2445 kg ha^{-1} in medium and shallow soil, respectively. Significant differences were observed for grain yield among the genotypes at all locations in both soils. On overall mean basis that in medium soils, BJV 348 and BJV 362 were produced higher yields but were not significantly superior to check *Phule Suchitra. Similarly*, in shallow soil, entries like BJV 371, 362, 129 and BRJ 2014 produced higher yield but it was significant as compared to check *Phule Suchitra.*

Trial 4RF and 4Irrg: Phenotyping sorghum for key root traits associated with drought adaptation: Thirteen advanced rabi sorghum genotypes along with checks were characterized for root and shoot related traits in controlled above ground root chambers under both irrigated (Irri) and water stressed (dry) conditions at Rahuri. Significant differences were observed for main effects and interactions for various physiological, root traits, shoot traits and yield components ($P \leq 0.05$. Mean plant height, decreased by 21.4 % in rainfed than irrigated. Mean LAI and SPAD declined by 25.8%, and 13% under moisture stress over control. CRS 50 and BRJ 229 were superior for above traits across moisture regimes. There was 21.9% decrease in biomass at flowering under moisture stress than irrigated control. CRS 50 and BRJ 229 were superior for above traits across moisture regimes. The other yield components like grain yield, dry fodder yield, 1000 seed weight also decreased by 31.5%, 32.0% and 15.2%, respectively, in rainfed condition than in irrigated. The mean root biomass, root length, root volume, and root numbers declined by 48.8%, 19.7%, 36.1%, and 36.2%, respectively, in rainfed condition than in irrigated. Mean root length at physiological maturity under rainfed condition varied from 45 to 60 cm/plant. Root number per plant at maturity varied in 33 to 45 in stress conditions. Root mass under moisture stress ranged 66 to 106 g/plant.

Detailed Report

In coordinated rabi sorghum physiology program, five trials were conducted at six locations Bijapur, Parbhani, Rahuri, Solapur, Tandur, and Gulbarga. The broad objectives of the rabi sorghum crop physiology program were to 1) preliminary evaluation of landrace germplasm (primarily local *durra biological races*) for traits related to drought adaptation, 2) to quantify putative crop physiological traits governing higher biomass and grain productivity combining drought and temperature stress (low and high) tolerance under receding soil moisture (stored) stress situation in a set of advanced genotypes and 3) identify potential and durable sources for utilizing in crop improvement programs. Identification of stress tolerant genotypes combining higher yields is important in view of current climate change and its variability. This ultimate goal of the program is to identifying contrasting sources/traits for tolerance/susceptibility that determine broad adaptation to climate change (drought, heat stress & combined (drought & heat)) that facilitate mapping population (RILs)/cultivar development, and QTL identification/analyses.

Trial 1R: Preliminary evaluation of diverse germplasm for rabi adaptation

(Table 1R.1.1 – 1R.1.8.)

Thirty-seven rabi sorghum landrace germplasm along with three checks were evaluated at Gulbarga, Parbhani, Tandur, Bijapur, Solapur and Rahuri with an objective of identifying potential donors for rabi adaptation traits such as phenology, physiological traits, components of biomass, and grain yield. These landrace germplasm were collected from different rabi sorghum growing areas of Karnataka, and Maharashtra. All the accessions were primarily belongs to the biological races either *durra or some caudatum types.* The crops were grown on medium vertisols under dryland conditions. The data are presented in table's 1R.1.1 – 1R.1.8.

Phenology and plant height: Mean days to flowering and days to physiological maturity differed significantly ($P \leq 0.05$) and were ranged from 71-87 d and 115-127 d, respectively. In general, average time taken for flowering was longer at Rahuri (87), followed by Gulbarga (79), and Bijapur (78). Least time to flowering was recorded at Solapur (71 d). Six entries flowered at least 2 days earlier than check CSV 22R (77) include RSV 1542, RSV 1749, RSV 1767, RSV 1850, SSRK 13-1 and SSRK 13-2 (72-75). The trend in days to physiological maturity was little different than flowering. Longest maturity time was at Rahuri (127) followed by Solapur (124) and Gulbarga (122). Only three entries RSV 1850, BJV 129 and SSRK 13-2 matured earlier (116-118) than check CSV 22R (119). Plant height differed significantly ($P \leq 0.05$) at different locations and ranged from 133 to 219 cm with an average of 183 cm. The plants becomes tallest at Parbhani (219 cm) followed by Solapur (2015 cm) and Gulbarga (188 cm). No entry was taller than check CSV 22R (207 cm).

Physiological traits: Leaf are index (LAI) at flowering varied significantly ($P \leq 0.05$) at different locations and ranged from 1.48 (Bijapur) to 3.32 (Rahuri) with a mean of 2.22. Although the variation across the entries dies not differ significantly, but it varies from 1.83 to 2.71 with highest in SSRK 13-1 (2.7) followed by RSV 1516 (2.64) and SLV 184 (2.58). The minimum LAI was recorded in SSRK 13-2 (1.83). Relative chlorophyll content (SPAD units) at flowering differed significantly ($P \leq 0.05$) at different locations and varied from 46.7 to 57.0 with an average of 50.8. Entries maintained higher SPAD include SSRK 13-15, RSV1850, SSRK 13-11 and RSV 1516 (55-56) than check CSV 22R.

Biomass components at flowering: Leaf dry weight at flowering, stem dry weight at flowering, total biomass at flowering differed significantly ($P \leq 0.05$). Total biomass at flowering ranged from 753 to 2485 g m^{-2}. No entry accumulated higher biomass at flowering than the check CSV 22R. On the other hand Genotypes produced significantly superior biomass yields than check CSV 22R includes SSRK 13-17, RSV 1516, SSRK 13-15, SSRK 13-4 and RSV 1785

Grain yield components: Grain yield, dry fodder yield, HI and 1000-seed weight differed significantly ($P \leq 0.05$) at all locations. Exceptionally high grain yields were obtained at Rahuri hence it was included in the analysis. Among the other five locations (Bijapur, Parbhani, Solapur, Gulbarga and Tandur) the average grain yield varied between 2077 to 2977 kg/ha. The highest grain yield was obtained at Parbhani followed by Solapur and Gulbarga respectively. Similarly, exceptionally higher dry fodder yields were obtained at Rahuri hence it was included in the analysis. Among the other five locations (Bijapur, Parbhani, Solapur, Gulbarga and Tandur) the average dry fodder yield varied between 5144 to 9537 kg/ha. The highest grain yield was obtained at Parbhani followed by Tandur and solapur respectively.

Average 1000 seed weight of genotypes varies from 29.2 to 42.5 g between the six locations. 1000 seed weight was highest at Parbhani followed by Solapur and Gulbarga. Genotypes with highest 1000 seed weight includes SLV 183 (39.4 g) followed by RSV 1542 (38.7 g) and SLV 181 (38.2 g), respectively. Similarly, average harvest index (HI) of genotypes varies from 24.2 to 35.2% between the six locations. HI was highest at Rahuri (35.2%) followed by Gulbarga (31.4%) and Solapur (26.3%). Genotypes with highest HI includes SSRK 13-2 (33.2%) followed by BJV 129 (32.1%) and BJV 362 (31.8%), respectively. In addition panicle dry weights were recorded at two locations i.e. Bijapur and Gulbarga. The average panicle weight was higher at Bijapur (731 g m^{-2}) than Gulbarga (535 g m^{-2}).

Trial 2(M) & 3(S): Phenotyping advanced rabi sorghum entries for drought adaptation traits in medium and shallow soils

(Tables 2M 2.1-2M2.5 and 3S 3.1- 3S.3.4).

Sixteen advanced rabi-adapted sorghum genotypes including three checks were phenotyped in both medium (≤75 cm soil depth) and shallow soils (≤45 cm soil depth) at Bijapur, Parbhani, Rahuri, Solapur and Tandur. Plant Breeders from different sorghum centres contributed these test materials which are at the advanced stage of development (stabilized F_6-$F_{7)}$. These materials were contributed based on their superior performance in the station and state MET trials. The test materials are primarily belongs to biological landrace *durra* which had specific adaptation to rabi season and said to be possessing relatively superior traits conferring tolerance to shoot fly, drought and heat, low temperature, pearly white and bold grain. The broad objectives of this trial were to evaluate advance rabi sorghum entries for putative traits (phenes) associated with drought adaptation and productivity across the soil depth (medium and shallow soils) and identify potential donors or contrasting parents for further crop improvement work. Testing was done in medium and shallow soils where development of flowering and post-flowering drought stress is rapid than deep soil. The testing hypothesis of genotypes across the soil depths is based on the farmers' practice of growing rabi sorghum with stored soil moisture in both soils in the target production area. Since the same set of entries were grown in both soils, the entries compared for their performance across the soil depths to identify the stable performing genotypes.

Crop phenology and plant height: Days to flowering and days to physiological maturity differed significantly ($P \leq 0.05$). Mean days to flowering differed between the soils depths. None was earlier to early check *Phule Anuradha* in both the soils. Similar trend was observed for days to maturity also. Significant difference ($P \leq 0.05$) was observed in plant height in both the soil depths at all the locations. Plant height ranged from 151 to 218 cm in medium and 141 to 165 cm in shallow soils. Average plant height decreased by 16.2 % in shallow soil over medium.

Physiological traits: Leaf area index (LAI) varied significantly ($P \leq 0.05$) at all locations in both soils depth. Mean LAI decreased by 33.0 % in shallow soil over medium. The variation of decreases in LAI among genotypes in shallow over medium soils was ranged between 25-42%. The minimum decreased in LAI in shallow soil as compared that in medium soil was observed in BJV 348 followed by BJV 129 and BRJ 204.

Leaf mass, stem mass, biomass differed significantly at flowering and maturity ($P \leq 0.05$). Average biomass production of two locations (Rahuri and Bijapur) at flowering decreased by 19.5 % in shallow soil over medium. The reduction biomass was more at Rahuri (45.2%) than Bijapur (10.2%). The variation of decreases in biomass accumulation among genotypes in shallow over medium soils was ranged between 6.8-37%. The minimum decreased in biomass accumulatio in shallow soil as compared that in medium soil was observed in Phule suchitra followed by CRS 49 and BJV 125.

Relative leaf water content (RLWC) recorded at flowering significantly ($P \leq 0.05$) varied at both Bijapur and Rahuri locations. RLWC at flowering reduced by 3.9% in shallow soil stress conditions over medium. Mean RLWC recorded was higher at Rahuri followed by Bijapur under both depths of soil. Almost all the genotypes maintained higher RLWC as compared to check *Phule Anuradha* in both the soils. RSV 1640 maintained highest RLWC in both type of soil, hence more stable in maintaining the crop water status .

Grain yield and its components: Grain yield, dry fodder yield, HI and 1000-seed mass differed significantly ($P \leq 0.05$) at all locations in both soil depths. Mean grain yield ranged from 2220 to 2965 kg ha^{-1} and 809 to 2445 kg ha^{-1} in medium and shallow soil, respectively. Grain yield decreased by 47.2% in shallow soil depth over medium. High mean grain yield was realized at Rahuri under medium depth soil, while it was at Bijapur under shallow soil depth. Significant differences were observed for grain yield among the genotypes at all locations in both soils. On overall mean basis that in medium soils, BJV 348 and BJV 362 were produced higher yields but were not significantly superior to check *Phule Suchitra. Similarly*, in shallow soil, entries like BJV 371, 362, 129 and BRJ 2014 produced higher yield but it was significant as compared to check *Phule Suchitra.* On the other hand most of entries were significantly superior in grain yield production in the shallow soil as compared to check *Phule Anuradha*.

Similarly mean dry fodder yield, 1000 seed weight and harvest index decreases by 36.7%, 17.4% and 8.3% under shallow soil as compared with that under medium depth soil, respectively. Although entries like CRS 50, BRJ 204, BJV 129 and CRS 49 produced substantially higher dry fodder yield than check *Phule Anuradha* under medium soil, but it was statistically non-significant. On the other hand, many entries were significantly superior in dry fodder production under medium soil as compared other check *Phule Suchitra*. There was no significant differences among the genotypes including checks in the mean harvest index under both medium and shallow soil. On the other hand mean 1000 seed weight differ significantly among the genotypes under both medium and shallow soil with CRS 49 recorded the highest 1000 seed weight under both the soil type as compared to other genotypes.

Trial 4 RF and 4 Irrg: Phenotyping sorghum for key root traits associated with drought adaptation

(Tables 4R.4.1 to 4.2)

Thirteen advanced rabi sorghum genotypes including checks were characterized for root and shoot related traits that contribute survival under flowering and postflowering drought and heat stress. Genotypes were evaluated in the specially constructed root structure facility at Rahuri. The root screening facility was specially created above the ground with required soil depth (1.0 m) and compaction as applicable to natural field conditions. This root screening facility was filled with vertisol and irrigated up to saturation prior to the sowing of. Entries were planted in split-plot design with two replications. Two water regimes namely i) rainfed and 2) limited irrigated (control) were assigned main-plots, while genotypes were allotted to sub-plots. The irrigated control treatment received 4-irrigations. The soil was brought back to near field capacity each time whenever irrigated.

Significant differences were observed for main effects and interactions for various physiological, root traits, shoot traits and yield components ($P \leq 0.05$) at Rahuri. There was significant decrease in root and shoot related traits under rainfed than in irrigated. Mean plant height, decreased by 21.4 % in rainfed than irrigated. Mean LAI and SPAD declined by 25.8%, and 13% under moisture stress over control. CRS 50 and BRJ 229 were superior for above traits across moisture regimes. Total biomass differed significantly among moisture regimes, genotypes including interaction effects. There was 21.9% decrease in biomass at flowering under moisture stress than irrigated control. CRS 50 and BRJ 229 were superior for above traits across moisture regimes. The other yield components like grain yield, dry fodder yield, 1000 seed weight also decreased by 31.5%, 32.0% and 15.2%, respectively, in rainfed condition than in irrigated. There was no significant decline in HI in rainfed condition than in irrigated. The mean root biomass, root length, root volume, and root numbers declined by 48.8%, 19.7%, 36.1%, and 36.2%, respectively, in rainfed condition than in irrigated. Mean root length at physiological maturity under rainfed condition varied from 45 to 60 cm/plant. Root number per plant at maturity varied in 33 to 45 in stress conditions. Root mass under moisture stress ranged 66 to 106 g/plant.

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