Sorghum Physiology - Rabi 2011-12

SS Rao coordinating with AICSIP's scientists

Contents

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Executive summary

Trial 1R: Preliminary evaluation of diverse germplasm for rabi adaptation: Days to flowering had shown (0.299; $P \leq 0.05$) positive correlation with 1000-seed weight, grain yield (0.263; ns), while negatively related with photosynthesis rate at anthesis ($r=-0.323$; $P \leq 0.05$). Entries Khadkat local, Honawad-2, SSRG164, and SSRG 206 had shown high SPAD values (52-53) than check CSV22R. High photosynthesis rate was recorded by RSV1478, Yadgir local, Mundewadi local, Patoda local and Halyal local which are superior to check Phule chitra. Land races Nimbodi local (47% more), Halyal local (29%), Honwad 2 (29%) and Bairodagi (20%) gave superior grain yields than check CSV22R.

Trial 2(M) & 3(S): Evaluation of advanced rabi sorghum entries for drought adaptation in medium in medium and shallow soils: Average plant height decreased by 13.2 % in shallow soil over medium. CRS 15 (0.649) and BRJ 204 (0.705) showed less drought susceptibility index (DSI) means more plant height stability. Plant height and days to flowering showed significant positive correlation with biomass mass at maturity (0.561, 0.507; $P \leq 0.05$ rep. in medium and shallow). LAI decreased in shallow soils over medium by 15.8%. Mean biomass decrease in shallow soils over medium was 33.5% and 37.0% at flowering and maturity, respectively. Entries, BRJ 204 in medium soil and RSV 1415 in shallow soils produced higher biomass at flowering and maturity in both soil depths. Relative water content (RWC) declined by 7.4 % in shallow over medium soils and CRS19 and CRS20 recorded high RWC than checks in both soils. Mean Photosynthesis rate (Pn) decreased by 9.1% in shallow soil over medium soil. BJV116, RSV1420 and RSV1098 showed significantly higher Pn rate than checks. Stover yield declined by 33.0 % in shallow soil over medium. DSI for stover yields at maturity, *Phule Anuradha* (0.462) and RSV 1420 (0.552) possessed lower DSI values means more stable performance under drought. Mean grain yield reduced by 38% in shallow soils over medium with a reduction range of 17 to 49 %. CRS20 (12%) CRS19 (7%) gave marginal superiority for grain yield in medium, while none was superior to check *Phule Anuradha* in shallow soil. *Phule Anuradha* recorded low DSI for grain (0.452) and stover (0.462) yields means more stable performance across the soil depths and possessing drought and heat stress tolerance in rabi receding soil moisture conditions.

Trial 4 R and 4 Irrg: Evaluation of sorghum plant types for root characteristics: Mean plant height, and grain yield decreased in rainfed condition by 10 and 50% over irrigated. Mean SPAD chlorophyll value decreased by 18 % in rainfed over irrigated. Average root length, root volume, and root numbers declined by 22, 50% and 37 % in rainfed condition than in irrigated. In root length under rainfed condition, none was superior to check Phule

Chitra. RSV1098 recorded higher root number in both rainfed and irrigated conditions. BJV83 alone recorded 20 and 16% more root mass than checks which was significantly ($P \leq 0.05$) different.

Trial 5R: Sweet sorghum evaluation for stalk yields, biomass, juice quality (sugar traits) and winter adaptation: SPSSV 30 was on par with check CSV19SS for fresh biomass and stalk yield. In juice brix, SPSSV30 alone recorded significantly higher (16%) than check CSV19SS. Similarly, SPSSV30 recorded 10.0 and 6.7% more TSS and sucrose content than check CSV19SS. Computed ethanol (EtoH) and sugar yields differed significantly ($P \leq 0.05$) and was ranged in 132 -548 Lha-1 and 0.68- 1.44 t ha $^{-1}$, respectively. Interestingly, SPSSV30 showed significant superiority by 51 and 107 % in EtoH and sugar yields, respectively. In grain yield, hybrid CSH 22SS gave highest, while in varieties SPSSV6, SSV84, SSV74 and SPSSV27 showed significant superiority over check CSV19SS.

Detailed report

Under coordinated rabi physiology program trials were conducted at Bijapur, Parbhani, Rahuri, Phaltan, and Tandur. A total of six trials were grown in rabi seasons. The objectives of the rabi physiology program were to 1) preliminary evaluation of land race germplasm for drought adaptation, 2) to characterize putative crop physiological traits in advanced entries that govern biomass, grain yield, drought and heat stress tolerance under stored soil moisture stress situation and 3) identify potential and durable sources for genetic enhancement of rabi sorghum. Identification of stress tolerance genotypes has greater importance in view of current climate change and variability. An additional trial on evaluation of advanced sweet sorghum entries for rabi conditions was also conducted.

Soils and planting: The soils where trials were planted varied from medium deep black (vertisols) to shallow soils. Planting was mainly done between mid-September and first or second week of week of October.

Environmental conditions at different rabi centers

(Tables Met 1- 3)

Rahuri: The total rainfall received during both kharif and rabi [standard week 23 (June 2011) to 5 (Feb 2012)] was 415 mm. This total amount received was far less than the normal. The total rainfall received during rabi season (Stnd week 36-5) between September first week and January end was just 114 mm. The rainfall occurred during rabi season in the second and third week are just adequate for sowing. The crop is exposed to terminal drought from October Middle onwards. Severe drought conditions were prevailing from GS 1 (preflowering) through GS 3 (postflowering). This is also reflected in the decrease of soil moisture especially in the upper profile (Table 1). Weekly mean minimum and maximum temperatures varied from 9.4 to 24.1°C and 29.0 to 35.0°C, respectively. The details of met data are presented in tables met 1–met 3.

Solapur: The rainfall received at Solapur during kharif and rabi cropping period and was 653 mm which is close to the normal (624 mm). The rainfall distribution revealed there was greater amount of rainfall occurred in kharif season (June, July and August). The rainfall received in rabi cropping period was 44% less than normal. While rainfall occurred during first fortnight of October was just enough for sowing and seed ling emergence. The crop was exposed to terminal drought from in October end until maturity. This erratic distribution of rainfall at Solapur resulted in poor performance of the crop especially in shallow soils. Weekly mean minimum and maximum temperatures varied from 11.0 to 25.0°C and 30.0 to 35.0°C, respectively. The details of met data are presented in tables met 1–met 3.

Bijapur: At Bijapur, the total rainfall received was 409 mm than the long term normal (590 mm), which was 31% less than long term average. The rainfall distribution was similar to Solapur with more rain occurring in Kharif than rabi season. The rainfall received in September far less than the normal. The rainfall occurred in early to mid-October was just adequate to plant the rabi sorghum. Hence, the rabi crop experienced both pre-and post-anthesis drought and heat stresses as could be seen from the rainfall data. Weekly mean minimum and maximum temperatures varied from 11.5 to 22.0°C and 29.0 to 33.0°C, respectively. The details of met data are presented in tables met 1–met 3.

Parbhani: At Parbhani, the total rainfall received was 621 mm that is less than normal for both kharif and rabi seasons. The rainfall received in kharif cropping season was higher and uniformly distributed. The rainfall occurred in early to September to early-October was just adequate to plant the rabi sorghum. Hence, the crop experienced both pre-and post-anthesis drought and heat stresses as could be seen from the rainfall data during the rabi season. Weekly mean minimum and maximum temperatures varied from 9.5 to 25.5.0°C and 25.5 to 36.5°C, respectively. The details of met data are presented in tables met 1–met 3. The total amount of rainfall received during rabi crop period i.e., standard week 37 (mid-sept) to 5 (Jan. end)) at Rahuri, Solpaur, Bijapur and Parbhani was 114,166, 127, and 144mm, respectively.

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

(Table 1R.1.1 – 1R.1.6.)

Forty-eight land races rabi sorghum germplasm along with three checks were evaluated at Parbhani, Tandur, Bijapur, Solapur and Rahuri with an objective of preliminary characterization of accessions for rabi adaptation traits such as phenology, components of photosynthesis rate, biomass, grain yield. The crops were grown on medium vertisols under dryland conditions. The data are presented in table's sum1R and 1R.1.1 – 1R.1.6.

Phenology and plant height: Mean days to flowering and days to physiological maturity differed significantly ($P \leq 0.05$) and was ranged from 68 -79 and 117-130 d, respectively. In general, days to flowering values were higher at Tandur (78) followed by Parbhani (77). At Bijapur the flowering duration was less. In general none was earlier to check to check *Phule Chitra* for days to flowering, but entries showed on par with check include SSRG170, SSRG236 and RSV 1460. The trend in days to physiological maturity was similar to flowering. Days to flowering had shown (0.299; $P \leq 0.05$) positive correlation with 1000-seed weight, grain yield (0.263; ns),while negatively related with photosynthesis rate at anthesis (r= -0.323; $P \leq 0.05$). Plant height differed significantly ($P \leq 0.05$) and ranged from 144 to 185 cm with an average of 165 cm. SSRG 202, SSRG204, Tansoli halli local, RSV1460 and Gondavle local grew taller than check.

Physiological traits: LAI flowering varied significantly ($P \leq 0.05$) and the range observed was from 2.60 to 5.27 with a mean of 3.70. Entries RSV 1462, RSV 1468 and SSRG164 showed higher LAI than checks. Relative chlorophyll content (SPAD units) at flowering differed significantly ($P \leq 0.05$) and varied from 37 to 53.0 with an average of 37 to 53. Entries Khadkat local, Honawad-2, SSRG164, and SSRG 206 had shown high SPAD values (52-53) than check CSV22R.

Photosynthesis rate (Pn), transpiration rate (Tp), stomatal conductance (rc) and leaf temperature differential (LTD) recorded at flowering varied significantly ($P \leq 0.05$) among the entries, and Pn ranged from 24.0 to 35.0 µ mol CO_2 m^{-1} S^{-1} . High Pn values were recorded by RSV1478, Yadgir local, Mundewadi local, Patoda local and Halyal local that are superior to check Phule chitra. SPAD values has no relationship with component of Pn. Interestingly, entry Yadgiri local showed high Pn in combination with high Tp and rc which might be possessing desiccation tolerance in stored soil moisture stress condition.

Biomass components and fodder yields: Leaf dry weight, stem dry weight, total biomass differed significantly ($P \leq 0.05$). None was superior to check CSV22R for leaf dry weight and stem dry weight and total biomass at flowering, and total biomass at flowering ranged from 88-286 g/ plant. High fodder yields were recorded by Mardi local, Tilehal local, RSV1462 and Katarkhatav local.

Grain yield components: Grain yield, HI and 1000-seed weight differed significantly ($P \leq 0.05$) at all locations. Mean 1000-seed weight ranged from 23.4 to 35.9 g and Bidar local, Pusegaon local, Tansoli halli local, and Jamkhed local 1 produced bolder grains (34.3 – 35.9 g) than checks. High mean grain yields were obtained at Bijapur and Rahuri. The grain yield of Solapur and Bijapur were not included in the pooled mean because of high CV. Average mean grain yield recorded was 2560, 1455, 746, 2751, and 1878 kg ha^{-1}, respectively for Parbhani, Rahuri, Solapur, Bijapur and Tandur. Land races Nimbodi local (47% more), Halyal local (29%), Honword 2 (29 %) and Bairodagi (20%) gave superior yields than check CSV22R. Mean HI ranged from 19.8 to 30.2 % with an average of 21.1 %. Entries SSRG 164, Bidar local, Honaward and Honaward-2 recorded high HI values than check. HI has shown high significant positive correlation with grain yields (0.316; P≤0.05), while the relationship of 1000- seed weight too positive but not significant (0.272;ns)

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

(Tables 2M 2.1-2M2.4 and 3S 2.1- 3S.3.3).

Sixteen advanced rabi-adapted sorghum genotypes including three checks have been evaluated in both medium (≤75 cm soil depth) and shallow soils (≤45 cm soil depth) at Bijapur, Parbhani, Rahuri, Solapur and Tandur. Plant Breeders from Rahuri, Bijapur, and Solapur contributed these materials based on the entries superior performance in the station and state MET trials. All the entries tested in this trial were stabilized at F_6 or F_7 level. The broad objective of this trial was to evaluate advance rabi sorghum entries for traits associated with drought adaptation across the soil depth (medium and shallow soils) and identify potential donors to utilize further in crop improvement work. Testing was done in medium and shallow soils where development of terminal drought stress is rapid than deed soil. The testing hypothesis of genotypes across the soil depths is based on the farmers' practice of growing rabi sorghum in both soils in the production area. Since the same set of entries were grown in both soils, the entries compared for their performance between the soil depths to identify the stable performing genotypes across the depths.

Data on important morpho-phonological, physiological traits, biomass, yield and its components were recorded as per standard procedures.Drought susceptibility index (DSI): DSI for plant height, biomass, stover and grain yield was calculated according to the Fischer and Maurer (1978) and the same is described below. DSI = (1 – Y/Yp)/D; where Y is the mean grain yield or biomass of a genotype in drought stress condition (shallow soil); Yp is the mean grain yield or biomass of same genotype in nonstress condition (medium soil) and D is the stress intensity D=1–X/Xp; where X is the mean Y of all genotypes; Xp is the mean Yp of all genotypes. DSI is used to characterize the relative drought tolerance of various genotypes (DSI≤0.50 highly stress tolerant, DSI >0.50 to ≤1.00 moderately stress tolerant, and DSI>1.00 susceptible).

Soil moisture status: Soil moisture content recorded at flowering stage was about 69% of available moisture indicating the prevalence of drought conditions. The moisture content decreased further decreased at maturity. The details of the soil moisture are presented in table 1. AS discussed previously, the rainfall received in GS 1 and G2 was almost nil at all rabi centres indicating the occurrence of terminal drought situation.

Table 1. Soil moisture particulars for advanced drought adaptation germplasm trial - Rabi 2011-12, Rahuri

S. No	Particulars	Medium				Shallow soil		
		0-15 cm	*15-30 cm*	*30-45 cm*	*45-60 cm*	*0-15 cm*	*15-30 cm*	*30-45 cm*
I	Soil moisture content (%)							
	a. At planting	32.2	30.7	30.6	30.6	32.8	31.2	31.8
	b. At Panicle initiation	31.5	29.8	32.3	33.5	34.8	33.7	32.3
	c. At 50% flowering	27.5	30.9	28.6	27.4	25.1	25.3	22.2
	d. At maturity	25.2	28.5	26.8	24.9	21.8	22.6	20.4
II	Available soil moisture content (%)							
	a. At planting	109	96	95	95	137	126	130
	b. At Panicle initiation	103	59	109	119	150	143	133
	c. At 50% flowering	69	98	78	69	86	86	66
	d. At maturity	50	78	63	48	63	68	54
III.	Field capacity (%)	31.2				27.3		
IV	Wilting point (%)	19.2				12.3		
V	Bulk density (g/cc)	1.28	1.29			1.3		
VI	Rainfall during crop period (mm)	415 mm						
	(standard week 38th - 5th)							
VII	Date of sowing	21/09/11				21/09/11		

Crop phenology and plant height: Days to flowering and days to physiological maturity differed significantly (P≤0.05). Mean days to flowering did not differ between the soils with an aaverage value of 73 d. None was earlier to 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 153 to 211 cm in medium and 133 to 182 in shallow soils. Average plant height decreased by 13.2 % in shallow soil over medium. BJV83 grew taller in both the soil depths. As regards DSI, entries CRS 15 (0.649), and BRJ 204 (0.705) showed less DSI means more plant height stability under drought than checks. Plant height and days to flowering showed significant positive correlation with biomass mass at maturity (0.561, 0.507; $P \leq 0.05$ rep. in medium and shallow).

Physiological traits: Leaf area index (LAI) varied significantly ($P \leq 0.05$) in both the soil depths. LAI ranged in 4.16-6.73 in medium and 3.42- 5.06 in shallow soils. Average LAI decreased in shallow soils over medium by 15.8%. BJV 03 in medium soil and CRS19 in shallow soils recorded higher LAI than checks. CRS 19 and CRS 20 were stable for LAI as the decrease in shallow was less.

Leaf mass, stem mass, biomass differed significantly at flowering and maturity ($P \leq 0.05$). Average biomass decrease in shallow soils over medium was 33.5% and 37.0% at flowering and physiological maturity, respectively. Entries, BRJ 204 in medium soil and RSV 1415 in shallow soils produced higher biomass at flowering and maturity in both soil depths than checks. In terms of DSI for biomass production at maturity, Phule Chitra (0.112) and RSV 1098 (0.379) gave stable performance under drought conditions.

Crop water status in terms of relative water content (RWC) recorded at flowering varied significantly. It declined by 7.4 % in shallow over medium soils. Entries CRS 19 and CRS 20 recorded high crop water status than checks in both soils. Stomatal frequency varied significantly at Rahuri. Significantly higher stomata were recorded on the lower leaf surface than upper in both soil types. Relative chlorophyll content (SPAD units) at flowering differed significantly ($P \leq 0.05$) and varied from 45-62 in medium and 42 to 53 in shallow soil. None was superior check Phule Anuradha in medium soil and BRJ 204 was superior in shallow soil for SPAD values.

Photosynthesis rate (Pn), transpiration rate (Tp), stomatal conductance (rc) and leaf temperature differential (LTD) recorded at flowering varied significantly ($P \leq 0.05$) among the entries. Pn ranged in 21.4-36.8 and 19.0- 32.0 μ mol CO_2 m^{-1} S^{-1} in medium and shallow soils, respectively .Mean Pn decreased by 9.1% in shallow soil over medium soil and range of decrease varied from 0.0l to 44.6 % among the entries. Entries, BJV116, RSV1420 and RSV1098 showed significantly higher Pn rate than checks in both medium m and shallow soil depths.

Stover yield at maturity differed significantly in both soil depths. Average stover yield recorded was 6.1 and 4.1 t ha^{-1} in medium and shallow soils, respectively. The stover yield was declined by 33.0 % in shallow soil over medium. Superior entries for stover yields include CRS20 and CRS 19 in medium soil and BJV114 and RSV1420 in shallow soil were superior. In terms of DSI for stover yields at maturity, *Phule Anuradha* (0.462) and RSV 1420 (0.552) possessed lower DSI values means more stable performance under drought conditions.

Grain yield and its components: Grain yield, HI and 1000-seed weight differed significantly ($P \leq 0.05$) at all locations. There is no much variation in 1000-seed weight and HI shallow and medium soils . Grain yield varied significantly at all locations in both soil depths. The CV (>25) for Solapur was high in both soil depths, hence the data could not be used for pooled mean.

Mean grain yield ranged from 2578 to 3360 kg ha^{-1} and 1416 to 2231 kg ha^{-1} in medium and shallow soil, respectively. The grain yield recorded at Solapur was lower in both the soils because of severe terminal drought conditions. At Bijapur, high grain yield was realized in both soils. Pooled grain yield data showed non-significantly differences, but CRS20 (12%) CRS19 (7%) gave marginal superiority in medium soil, while none was superior to check Phule Anuradha in shallow soil. Mean grain yield reduced by 38 % in shallow soils over medium with the range of reduction varied between 17 to 49 %.

In terms of DSI for grain yields, none was superior to check *Phule Anuradha* (DSI=0.452). This entry being early in flowering (60-64 d) had possessed drought tolerance mechanism (through escape or avoidance) resulting in higher biomass and grain yield sunder sever terminal drought and heat stress conditions when the crop is grown with stored soil moisture. The comparison between grain and stover yields is presented in Fig. 1. Interestingly, *Phule Anuradha* showed low DSI for both grain and stover yields means more stable and stress tolerance in terminal drought rabi condition. Other entries which exhibited relatively lower DSI values were BRJ204 (0.728), BJV103 (0.810), Phule Chitra (0.852) and BJV114 (0.876).

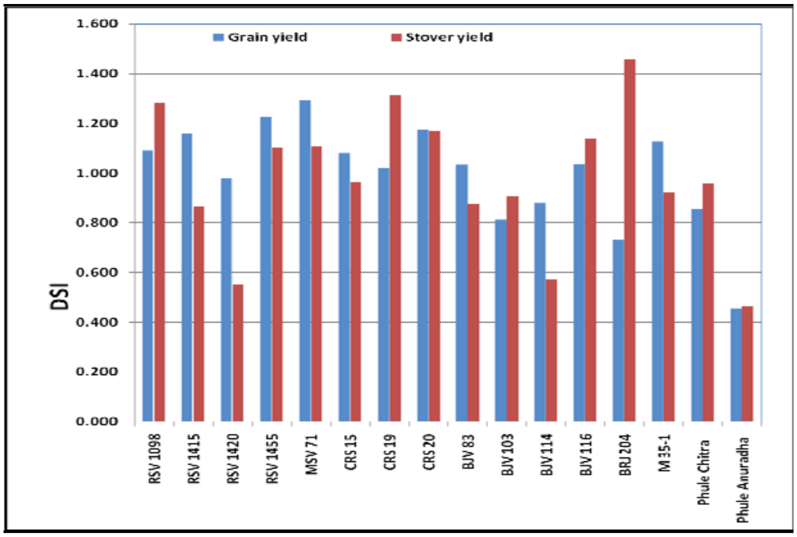

Fig. 1 Drought susceptibility index (DSI) for grain and stover yield in 16 rabi sorghum entries. The values are mean of three locations. DSI is calculated according to the Fischer and Maurer (1978). (DSI≤0.50 highly stress tolerant, >0.50 to ≤1.00 moderately stress tolerant, and >1.00 susceptible).

Trial 4 R and 4 Irrg.: Evaluation of sorghum plant types for root characteristics.

(Tables 4.1-4.2 R & 5.1-5.2 Irrg.).

Thirteen advanced rabi sorghum genotypes including checks were characterized for root and shoot traits that contribute survival under drought stress. Genotypes have been evaluated in the root structure facility at Rahuri in as specially created above the ground with required soil depth (1.0 m) and compaction were maintained. This root screening facility was filled with vertisol at saturated to nest field capacity at the beginning of the season. Entries were planted in two sets one rainfed and another under irrigated (2 to 3 irrigations) as control. Although, the data received from Bijapur is included in the report but not compared with Rahuri as the procedure followed was not similar to that Rahuri.

Phenology, shoot mass, root mass, root length, root volume, root number varied significantly (P≤0.05) at Rahuri. There was significant decrease in root and shoot related traits under rainfed than in irrigated. Mean plant height, grain yield decreased in rainfed condition by 10 and 50% over irrigated. None was superior to checks for grain yields in both conditions. Entries, RSV1429, RSV1410 and RSV1098 were significantly superior for photosynthesis rate at flowering than checks in irrigated, while none was superior to checks in rainfed. Mean SPAD chlorophyll value decreased by 18 % in rainfed over irrigated.

The mean root length, root volume, and root numbers declined by 22, 50% and 37 % in rainfed condition than in irrigated. Root length at physiological maturity under rainfed condition varied from 44 to 77 cm/plant, none was superior to check Phule Chitra in stress conditions. Similar trend was observed for root volume too. Root number per plant at maturity varied in 23 to 50 and 46 to 92, respectively for rainfed and irrigated conditions. Interestingly, RSV 1098 recorded higher root number in both rainfed and irrigated conditions. Data on root mass in irrigated appears to be too high peer plant, hence not considered for comparison with rainfed. Root mass at maturity in rainfed condition ranged from 25 to 71g /plant. BJV83 alone recorded 20 and 16% more root mass than checks which was significantly different (P≤0.05).

Trial 5R: Sweet sorghum evaluation for stalk yields, biomass, juice quality (sugar traits) & winter adaptation

(Tables 5R 6.1 – 5R 6.4)

Twelve advanced sweet sorghum genotypes including two varietal (CSV19SS, SSV84) and one hybrid check (CSH22SS) were evaluated at four locations (Phaltan, Rahuri and Parbhani) with an objective of performance of these entries for stalk yield, biomass, sugar quality traits besides winter season (rabi) adaptation. The sweet sorghum genotypes which perform well in kharif season generally yield poorly because of photoperiod sensitivity. There is the limited information available on sweet sorghum for rabi adaptation. The crops were raised with minimal supplemental irrigation (2 #) and planted during first week of October 2011.

Phenology and Plant height: Days to flowering and maturity differed significantly ($P \leq 0.05$) at all locations and the mean values ranged from 70 to 81 and 117 to 128 d, respectively. Duration to flowering was similar at Parbhani and Phaltan, while it delayed at Rahuri. None was found significantly earlier to check CSV19SS for flowering and maturity. Plant height differed significantly ($P \leq 0.05$) and mean values varied between 155 (SPV913) and 253cm (SPSSV30) across locations.

Fresh biomass and stalk yield: Fresh biomass differed significantly ($P \leq 0.05$) and none was superior to check for fresh biomass at both locations, while SPSSV 30 was on par to check CSV19SS. Hybrids check CSH 22SS is not competitive (superior) to variety check in total biomass. Fresh stalk yield too differed significantly ($P \leq 0.05$) and none was superior to check at both locations, while SPSSV 30 was marginally superior to check.

Juice quality and sugar traits and grain yields: Juice brix differed significantly ($P \leq 0.05$) and was ranged from 8.8 (SPV422) to 17.0% (SPSSV30) with a mean of 11.6%. Entry SPSSV30 alone recorded significantly higher (16% higher) than best check CSV19SS. The juice yield varied from 4.8 to 13.4 KL ha^{-1} and SPSSV 30 recorded significantly higher (31.5%) juice yield than check CSV 19SS. Total soluble sugars (TSS), non-reducing sugars (sucrose) and reducing sugars differed significantly ($P \leq 0.05$).SPSSV30 recorded 10.0 and 6.7% more TSS and sucrose content than check CSV19SS. Mean juice extraction differed significantly ($P \leq 0.05$) and was ranged from 18.6 to 29.4% with an average of 24.4%. SPSSV11 and SPSSV 30 were on par with check CS 19SS.

Computed ethanol (EtoH) and sugar yields differed significantly ($P \leq 0.05$) and was ranged in 132 -548 Lha-1 and 0.68- 1.44 t ha^{-1}, respectively. Interestingly, test entry SPSSV30 showed significant superiority by 51 and 107 % in EtoH and sugar yields, respectively.

Grain yield differed significantly ($P \leq 0.05$) parbhani and phaltan and was ranged in 1.54 -5.20 and 1.25-6.1 t ha^{-1}, respectively. Pooled mean indicated that hybrid CSH 22SS gave highest yields among the entries. Verities, SPSSV6, SSV84, SSV74 and SPSSV27 showed significant superiority over check CSV19SS.

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