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The effect of morphological parameters in sweet sorghum hybrids (*Sorghum bicolor* (L.) Moench)

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Abstract
The present investigation entitled "Studies on physiological parameter in sweet sorghum hybrids {*Sorghum bicolor* (L) Moench}" was undertaken to study the to study the effect of morphological parameter. The experiment was conducted at Sorghum Research Station, Vasantrao Naik Marathwada Agricultural University, Parbhani during the *Kharif* season of 2022-2023 under field conditions. The Randomized Block Design with three replications was used for the experiment of 32 genotypes of sweet sorghum hybrids. The results revealed that, Among the hybrid genotypes, plant height, leaf area, leaf area index, Specific leaf area and Specific leaf weight were recorded maximum in the genotype IIMR35A×ICSV17472 (339.00 cm), 3026A×RSSV466 (66.6 dm^2), 3026A×RSSV466 (3.66 cm^2/ cm^2), RMS10A×SSR7 (0.12 cm^2/mg) and IIMR33A×ICSV17472 (9.77mg/cm^2) respectively as compared to all other hybrid genotypes. The various physiological parameters *viz*., Relative water content 296A×ICSV1502-1(86.67%) and SCMR value was higher in hybrid genotypes IIMR15A x RSSV589 (SCMR value 60) respectively as compared to all other genotypes. Among the phenological parameters *viz*., Days to 50% flowering of hybrid genotype PMS71A×AKSV473R (94 days) and days to physiological maturity of hybrid genotype 3060×11NRL (131.00 days) was observed late as compared to all other hybrid genotypes. The genotypes AKMS 90A×I-7 (scale 7) and PMS-71A×11NRL (scale-7.13) showed yellow green dry leaves at the harvest stage. The genotype AKMS30A×AKSV472R and AKMS90×SSV74 (scale 3.07) green leaf at harvest stage.

Keywords: Sweet sorghum, physiological, flowering, genotype, RBD

1. Introduction
Sorghum bicolor (L.) Moench is the proper name for the cultivated variety of sorghum. The greatest juice content of sweet sorghum (*Sorghum bicolor* (L.) Moench) sets it apart from grain sorghum. It has a juicy, sweet stem and is frequently taller—up to four meters. Dry land growing locations can successfully cultivate it. It's referred to as the "camel among crops," the "smart" crop, and the sugarcane of the desert. Just one-seventh as much water is extracted by sweet sorghum as by sugarcane. Sweet sorghum is used to produce industrial biofuel as well as grain for human use and stover for animal feed. One crop seldom meets the three needs of food, fodder, and fuel at the same time. It has a higher overall. (Mokariya L.K. and Malam K.V. 2020) [14].

In Maharashtra, sorghum crop is grown in area of 15.40 lakh hectare, out of which 2.94 and 12.46 lakh hectare grown in Kharif and Rabi seasons with an average production of 2.72 and 5.15 lakh tons and productivity of 923 and 481 kg per hectare, respectively (maha-agri.org, 2019). The first three largest producing states are Maharashtra, Karnataka, and Madhya Pradesh respectively. (Anonymous, 2019) [2-3].

Distinct morphological and physiological traits of sorghum are associated with its ability to maintain cellular metabolism and water uptake, reduce evapotranspiration and oxidative stress under conditions of limited soil water and excessive atmospheric temperatures. The unique traits of sorghum associated with its leaves, root plasticity, timing of critical phenological events and biochemical changes that result in reduced physical injuries and physiological disruption when exposed to heat and drought stress need to be fully understood. Thus the extent of acclimation of sorghum to these environmental stresses can only be understood by examining its morphological and physiological traits that underlay mechanisms of avoiding, escaping or tolerating stress related effect. It is against this background that this article reviewed the morphological and physiological responses of

sorghum along with its resistance mechanisms to drought, heat and combined stresses. As such this review attempts to draw a synthesis of available literature on independent and combined effects of drought and heat stresses.

2. Materials and Methods

2.1 Morpho-Physiological Characters

2.1.1 Plant height (cm)

The plant height (cm) of the randomly selected plants from each net plot was recorded in cm by measuring from the base of plant near the ground up to the base of fully expanded leaf. After emergence of panicle, the height was measured upto the panicle. The plant height was recorded at 30 days interval starting from 30 days after sowing upto harvest.

2.1.2 Number of leaves per plant

Number of green leaves (more than 50% green portion on five randomly selected plants was counted and the mean number per plant was calculated at 30, 60 90 das and at harvest.

2.1.3 Leaf area (dm^2) per plant at 50% flowering

The leaf area of the plant was calculated by taking maximum length and width at the broadest point of the green leaves and multiplying by the factor 0.747 (stickler *et al.* 1961) [21].

$$LA = L \times B \times K \times N$$

Where,
LA = Leaf area in cm^2
L = Length of the leaf in cm B = Breadth of the leaf in cm
K = Leaf area constant (0.747) N = No. of leaves/plants

2.1.4 Leaf Area Index At 50% Flowering

The leaf area index was calculated at different crop growth stages by dividing the leaf area per plant by land area occupied by the plant and is the defined as the assimilatory surface area per unit land area (Ashley *et al.*, 1963) [4].

$$LAI = \frac{\text{Leaf area}}{\text{Ground area}}$$

2.1.5 Specific leaf weight at 50% flowering.

The specific leaf weight or the leaf thickness was determined by the following formula and is expressed as mg/dm^2. (Landberg 1990) [13]

$$SLW = \frac{\text{Leaf dry weight (mg)}}{\text{Leaf area } (cm^2)}$$

2.1.6 Day to physiological maturity

The physiological maturity was identified by sampling seeds daily, appearance of black spot on hilum was taken for daily harvested seeds for identifying the stage of physiological maturity. The number of days required from sowing till the date, when seed matured physiologically was recorded.

2.1.7 Total biomass at physiological maturity

Total fresh biomass including panicles was recorded at physiological maturity.

$$\text{Total fresh biomass (t/ha)} = \frac{\text{Total fresh biomass (kg/net plot) x hectare factor}}{1000}$$

2.1.8 SCMR value at 50% flowering and 25 days after flowering

SCMR value was measured using SPAD chlorophyll meter (Minolta SPAD-502 meter, Tokyo, Japan). The data was expressed as SPAD unit (Hoel, 1998) [9].

2.1.9 Relative water content at 50% flowering and 25 days after flowering

The relative leaf water content (RLWC) was determined according to the modified method of Bars and Weatherly (1962) [6] at flowering stage and it was expressed in percentage.

$$\text{Relative water content (\%)} = \frac{\text{Fresh weight – dry weight}}{\text{Turgid weight – dry weight}} \times 100$$

3. Results and Discussions

3.1 Morpho-Physiological Parameter

The observations on the growth characters such as plant height, number of leaves, leaf area, specific leaf area, and specific leaf weight were recorded at 50% flowering and data are presented in Tables revealed that all the characters were found statistically significant at all stages.

3.1.1 Number of green leaves per plant

The relevant periodical data pertaining to number of leaves per plant are represented in table 1 the difference in number of leaves per plant due to different sweet sorghum hybrid genotype were statistically significant at all growth stage i.e., 30, 60 and 90 DAS. it was revealed that in all sweet sorghum hybrid genotypes, the number of leaves per plant increased gradually up to 90 DAS and show declining trend toward maturity. At 30 DAS the number of leaves per plant highest in hybrid genotype IIMR 13A x RSSV589 (5.40 leaves) followed by IIMR15A x RSSV589 and AKMS 90A x AKSV4 72R, 473A x RSSV 52 (5.33 leaves/plant).
The hybrid IIMR 28A x ICSV 18002 recorded significantly lowest number of leaves (4 leaves/plant). At 60 DAS the hybrid 3026A x RSSV 466 recorded significantly highest no of leaves per plant (9.67) followed by ICSA 38 x SPV 2074 (8 leaves/plant) the hybrid 8914A x ICSV 17335 recorded significantly lowest number of leaves/plant (5.67 leaves/plant). At 90 DAS, the number of green leaves per plant ranged between 9.67 and 12 with mean of 10. 43, the hybrid 3026A x RSSV 466 recorded significantly highest mean number of green leaves per/plant (12.00), which was at par with hybrid AKMS 90A × AKSV472R and 2297A x RSSV260. Whereas AKMS30A x 11NRL recorded significantly lowest number of leaves per plant as compare to another hybrid genotype.

Table 1: No of green leaves per plant as influenced by sweet sorghum hybrid

Genotypes	30 Days after sowing	60 Days after sowing	90 Days after sowing
AKMS 30A x RSSV 522	4.50	7.00	10.00
AKMS 30A x 11 NRL	4.33	6.00	9.67
AKMS 30A x AKSV 472R	5.00	7.33	10.00
AKMS 90A x RSSV 522	4.67	7.67	10.87
AKMS 90A x AKSV 472R	5.33	6.33	10.53
AKMS 90A x SSV 74	5.33	6.33	10.67
AKMS 90A x I-7	4.67	6.67	10.40
PMS 42A x RSSV 522	5.33	7.33	10.00
PMS- 71A x AKSV 473R	4.67	7.33	10.33
PMS- 71A x 11 NRL	5.33	6.67	10.47
RMS 10A x SSR 7	4.83	6.67	11.00
IIMR 28A x ICSV 18002	4.00	7.00	10.07
IIMR 33A x ICSV 17472	5.00	7.00	10.33
IIMR 35A x ICSV 17472	3.67	6.67	11.33
473A x ICSV 1502-1	4.00	7.00	10.10
473A x RSSV 522	5.33	6.67	10.33
2297A x RSSV 260	4.67	7.33	10.67
3060A x RSSV 260	4.33	7.33	10.00
3060A x 11 NRL	4.67	7.33	10.90
8914A x ICSV 17335	4.00	5.67	10.93
8914A x RSSV 589	5.00	6.67	10.87
8914A x RSSV 260	4.33	7.33	10.83
IIMR 13A x RSSV 589	5.40	8.00	10.73
IIMR 15A x RSSV589	5.33	7.67	11.00
IIMR 15A x RSSV 542	5.00	8.00	10.67
IIMR 15A x RSSV 522	4.67	7.00	11.33
IIMR 15A x 11NRL	5.00	7.33	11.30
3026A x RSSV 466	6.00	9.67	12.00
296A x ICSV 1502-1	4.33	7.67	10.33
ICSA 38 x SPV 2074	4.67	8.00	10.00
185A x 11 NRL	5.67	6.67	10.33
CSH 22 SS (check)	4.67	7.67	10.33
GM	4.69	6.86	10.43
S.E m. ±	0.37	0.44	0.49
C.D. at 5%	1.07	1.27	1.50
C.V. %	13.8	11.16	12.45

Nakamura *et al.,* (2011) [17] reported that the number of leaves per plant increases up to 90 DAS their after the number of leaves decreases with maturity stage. Meena *et al.,* (2017) [15] also reported that similar result in variety SPV-2185 recorded maximum number of leaves.

3.1.2 Leaf area (dm^2) per plant at 50% flowering

The data pertaining to leaf area plant^{-1} (dm^2) are presented in Table 2, variations in leaf area plant^{-1} due to the different sweet sorghum hybrid were statistically significant at 50% flowering. it was revealed that the mean leaf area was increased rapidly up to 90 DAS and declined toward the harvest stage. At 50% flowering, the leaf area plant^{-1} (dm^2) ranged between 51.27 to 66.6 dm^2 with a mean of 60.33 dm^2. The hybrid 3026A × RSSV 466 recorded significantly highest mean leaf area plant^{-1} (66.6 dm^2), which was at par with AKMS 90 × SSV 74. The hybrid AKMS 30A ×11 NRL recorded significantly the lowest mean leaf area plant^{-1} (51.27 dm^2), followed by AKMS 30A × RSSV 522 and IIMR 28A × ICSV 18002.

Similar result was reported by Sathe *et al.,* (1997) [19] that maximum leaf area was observed at flowering in *rabi* sorghum hybrids and varieties and thereafter declined towards maturity. Rape (2012) also reported that the maximum leaf area (38.90 dm^2) was observed at 60-90 DAS.

3.1.3 Leaf area index (cm^2/cm^2) per plant at 50% flowering

The data pertaining to leaf area index per plant (cm^2/ cm^2) are presented in Table 2. The variations in leaf area index plant^{-1} due to the variation in sweet sorghum hybrid genotypes which were statistically significant at 50% flowering. Whereas the mean leaf area index was increased rapidly up to 90 DAS and declined toward the harvest stage. At 50% flowering, the leaf area index per plant (cm^2/ cm^2) ranged between 2.77 to 3.66 with a mean of 3.30 (cm^2/cm^2). The hybrid 3026A × RSSV 466 recorded significantly highest mean leaf area index per plant (3.66 cm^2/ cm^2) which was at par with AKMS 90 × RSSV 522. The hybrid AKMS 30A × 11 NRL recorded significantly lowest mean leaf area index per plant (2.77 cm^2/ cm^2), followed by AKMS 30A × RSSV 522, IIMR 28 × ICSV 18002 and CSH22 SS (check). Addai and Alimiyawo (2015) [1] reported that the leaf area index showed positive relation with the grain yield**.**

Table 2: Leaf area and Leaf area index as influenced by sweet sorghum hybrid

Genotypes	Leaf area at 50% flowering (dm^2)	Leaf area index at 50% flowering (cm^2/cm^2)
AKMS 30A x RSSV 522	52.37	2.83
AKMS 30A x 11 NRL	51.27	2.77
AKMS 30A x AKSV 472R	57.43	3.13
AKMS 90A x RSSV 522	57.50	3.19
AKMS 90A x AKSV 472R	60.13	3.34
AKMS 90A x SSV 74	62.17	3.44
AKMS 90A x I-7	60.87	3.33
PMS 42A x RSSV 522	62.03	3.40
PMS- 71A x AKSV 473R	56.71	3.12
PMS- 71A x 11 NRL	62.37	3.36
RMS10A x SSR 7	62.60	3.35
IIMR 28A x ICSV 18002	55.63	2.97
IIMR 33A x ICSV 17472	66.53	3.50
IIMR 35A x ICSV 17472	56.93	3.20
473A x ICSV 1502-1	62.80	3.43
473A x RSSV 522	63.03	3.50
2297A x RSSV 260	64.40	3.57
3060A x RSSV 260	63.13	3.49
3060A x11 NRL	63.07	3.47
8914A x ICSV 17335	65.77	3.67
8914A x RSSV 589	59.07	3.16
8914A x RSSV 260	60.60	3.30
IIMR 13A x RSSV 589	62.47	3.65
IIMR 15A x RSSV589	59.07	3.23
IIMR 15A x RSSV 542	61.07	3.49
IIMR 15A x RSSV 522	56.40	3.10
IIMR 15A x 11NRL	62.67	3.43
3026A x RSSV 466	66.60	3.66
296A x ICSV 1502-1	62.87	3.48
ICSA 38 x SPV 2074	62.54	3.37
185A x 11 NRL	61.17	3.37
CSH 22 SS (check)	59.50	2.93
GM	60.33	3.30
S.E m.±	1.15	0.16
C.D. at 5%	4.5	0.46
C.V. %	7.66	8.48

3.1.4 Specific leaf area per plant at 50% flowering

The data pertaining to specific leaf area per plant (cm^2/mg) are presented in Table 3. The variations in specific leaf area per plant due to the different sweet sorghum hybrid which, were statistically significant at 50% flowering. At 50% flowering the specific leaf area ranged from 0.11 (cm^2/mg) to 0.12 (cm^2/mg), the hybrid RMS 10A × SSR 7 and AKMS 30A × 11 NRL recorded significantly highest specific leaf area per plant. Whereas they are found at par with AKM 30A × RSSV 522, IIMR 25A × IDSV 17472 and IIMR 33A × ICSV 14472.

3.1.5 Specific leaf weight per plant at 50% flowering

The data pertaining to specific leaf weight per plant (mg/cm^2) are presented in Table 3. The variations in specific leaf weight $plant^{-1}$ due to the different sweet sorghum hybrids which were found statistically significant at 50% flowering. At 50% flowering specific leaf weight ranged from 7.63 (mg/cm2) to 9.77 (mg/cm^2). The hybrid IIMR 33A × ICSV 17472 recorded significantly highest specific leaf weight, which was at par with IIMR 15A × 11NRL, 3060A × RSSV 260, and AKMS 90A × RSSV 522. The hybrid IIMR15A× RSSV 542 recorded significantly lowest leaf weight among the rest of hybrid genotype.

3.2 Phenological parameter

3.2.1 Mean Day to 50% flowering

The mean days for 50% flowering was reported in table 4. The mean days for 50% flowering were significantly differed due to various hybrid genotypes. The hybrid PMS 71A × AKSV 473R was recorded significantly highest mean days for 50% flowering (94.00 days), followed by the hybrid 3060A × RSSV 260 (93.00 days) was found second-best genotype as compared with rest of genotypes with respect of means days for 50% flowering. However, the hybrid IIMR 15A×RSSV 542 (82.33 days) was recorded significantly lowest mean days for 50% flowering, followed by the hybrid 185A×11NRL (82.50 days) and 8914A × RSS V260 (82.60 days). Mean number of days required for 50% flowering were (87.96 Day). The genotype IIMR 15A × RSSV 542 flowered earlier than all other genotypes. Norem *et al*. (1985) [23] had found genotypic differences in days required for 50% flowering in *rabi* sorghum genotypes. Nirmal *et al.*, (2017) [18] reported that the genotype RSSV-381 showed 50% flowering at (66 DAS), which was earlier than CSV-19SS (75 DAS), RSSV- 350 (78 DAS), and RSSV-313 (79 DAS) respectively.

Table 3: Specific leaf area and Specific leaf weight influenced by sweet sorghum

Genotype	Specific leaf area at 50% flowering (cm^2/mg)	Specific leaf weight at 50% flowering (mg/cm^2)
AKMS 30A x RSSV 522	0.11	9.05
AKMS 30A x 11 NRL	0.13	7.80
AKMS 30A x AKSV 472R	0.12	7.70
AKMS 90A x RSSV 522	0.12	8.47
AKMS 90A X AKSV 472R	0.12	7.97
AKMS 90A x SSV 74	0.12	7.93
AKMS 90A x I-7	0.12	8.10
PMS 42A x RSSV 522	0.12	8.01
PMS- 71A x AKSV 473R	0.12	8.08
PMS- 71A X11 NRL	0.11	9.18
RMS 10A x SSR 7	0.13	8.14
IIMR 28A x ICSV 18002	0.12	8.58
IIMR 33A x ICSV 17472	0.11	9.77
IIMR 35A x ICSV 17472	0.11	9.40
473A x ICSV 1502-1	0.12	8.22
473A x RSSV 522	0.12	8.43
2297A x RSSV 260	0.12	9.53
3060A x RSSV 260	0.11	8.40
3060A x11 NRL	0.11	8.50
8914A x ICSV 17335	0.12	7.88
8914A x RSSV 589	0.11	7.96
8914A x RSSV 260	0.12	7.97
IIMR 13A x RSSV 589	0.12	8.30
IIMR 15A x RSSV589	0.11	8.63
IIMR 15A x RSSV 542	0.12	7.63
IIMR 15A x RSSV 522	0.12	8.37
IIMR 15A x 11NRL	0.12	8.43
3026A x RSSV 466	0.12	8.33
296A x ICSV 1502-1	0.12	8.13
ICSA 38 x SPV 2074	0.11	7.90
185A x 11 NRL	0.12	8.07
CSH 22 SS (check)	0.12	8.00
GM	0.119	8.45
S.E. m ±	0.01	0.47
C.D. at 5%	0.02	1.33
C.V. %	8.42	9.54

3.2.2 Day to physiological maturity

The mean day to physiological maturity was presented in table 4. The periodical mean day for physiological maturity was differed due to different hybrid genotypes. The hybrid 3060A ×11 NRL recorded significantly highest mean days for physiological maturity (131.00 days), followed by the genotype PMS-71A × AKSV473R (130.00). However, the genotype 185A × 11 NRL recorded significantly lowest mean days for physiological maturity (116.00 days), followed by the genotypes AKMS 30A × RSSV 522 (117 days). Mean number of days required for physiological maturity were (124.73 days). The genotype 185A × 11 NRL (116.00 days), followed by AKMS 30A × RSSV 522 (117 days) matured earlier than all other genotypes. When grown on stored soil moisture, early maturity of a genotype helps to escape terminal moisture stress. Similar results were reported by Kadam *et al*. (2002) [10].

3.2.3 Plant height (cm) at physiological maturity

The data on mean plant height is presented in Table 4. The present investigation revealed significant differences in plant height among the hybrids at physiological maturity stages Indicate that the height of the plant increased rapidly up to 90 DAS after sowing and the increase rate was slow thereafter.

The differences in plant height of the hybrid were significant at all stages. The plant height was maximum in hybrid IIMR 35A × ICSV 17472 (339.00 cm) followed by PMS 71A × AKSV 473R (330.00 cm). The lowest plant height was observed in 473A × ICSV 1502-1 (264.67 cm) at maturity stage.

The present investigation revealed significant differences in plant height among the hybrid at physiological maturity stages. Similar result also reported by Mutkule (2010) [16] that the mean plant height of sweet sorghum at maturity was highest during *kharif* (275 cm) than *rabi* season (219 cm). Shinde *et al*., (2013) [20] reported that range of plant height from 184.5 to 247.5 cm.

3.3 Physiological parameters

3.3.1 Relative water content at 50% flowering

The mean value of relative water content at 50% flowering reported in table 5. The studies on physiological parameters included the estimation of relative leaf water content as important criteria to determine the potential of any genotype for its tolerance to drought conditions. Relative water content of leaf (RWC) indicates the actual water content to its maximum turgidity. The data on mean values of relative leaf water content are presented in Table 5 The data showed significant differences in relative leaf water content among the hybrids. The hybrids 296A × ICSV 1502-1 (86.67%) recorded significantly higher relative leaf water content followed by 3060A × RSSV 260 (86.33%) and PMS 42A × RSSV 522 (85.67%). The lowest relative water content was

observed in IIMR 15A × RSSV 522 (72%). followed by CHS22 SS (74.00%). Shinde *et al*., (1998) [20] also reported that water use efficiency, relative water content and yield attributes were significantly correlated with grain yield in sorghum.

Table 4: Phenological parameter as influenced by sweet sorghum hybrid

Genotype	Days to 50% flowering	Days to physiological maturity	Plant height at physiological maturity (cm)
AKMS 30A x RSSV 522	83.00	117.33	310.33
AKMS 30A x 11 NRL	84.33	120.07	291.00
AKMS 30A x AKSV 472R	79.67	120.67	318.00
AKMS 90A x RSSV 522	92.00	129.67	293.00
AKMS 90A x AKSV 472R	87.33	124.33	295.67
AKMS 90A x SSV 74	90.00	125.67	308.33
AKMS 90A x I-7	85.67	122.67	285.67
PMS 42A x RSSV 522	88.33	122.67	282.00
PMS- 71A x AKSV 473R	94.00	130.00	294.00
PMS- 71A x11 NRL	85.67	121.00	330.00
RMS 10A x SSR 7	92.00	129.00	296.00
IIMR 28A x ICSV 18002	91.00	125.00	297.33
IIMR 33A x ICSV 17472	88.00	123.33	300.00
IIMR 35A x ICSV 17472	88.00	124.33	339.00
473A x ICSV 1502-1	89.00	127.67	264.67
473A x RSSV 522	86.00	125.00	296.67
2297A x RSSV 260	85.33	116.00	299.33
3060A x RSSV 260	93.00	128.00	297.33
3060A x11 NRL	91.00	131.00	322.67
8914A x ICSV 17335	86.00	122.67	298.67
8914A x RSSV 589	85.00	122.67	303.00
8914A x RSSV 260	82.60	129.00	304.00
IIMR 13A x RSSV 589	87.33	126.00	300.67
IIMR 15A x RSSV589	91.33	124.00	286.00
IIMR 15A x RSSV 542	82.33	118.00	300.67
IIMR 15A x RSSV 522	90.00	127.00	301.00
IIMR 15A x 11 NRL	85.33	123.33	282.33
3026A x RSSV 466	92.00	129.67	312.33
296A x ICSV 1502-1	85.33	123.00	290.33
ICSA 38 x SPV 2074	89.33	130.00	296.33
185A x 11 NRL	82.50	116.00	279.33
CSH 22 SS (check)	86.33	123.00	308.67
GM	87.96	124.73	300.98
S.E. m. ±	2.33	2.52	12.40
C.D. at 5%	6.67	7.23	35.51
C.V. %	4.58	3.5	7.13

Relative water content 25 days after flowering

The data on mean values of relative leaf water content are presented in 4.5. The data showed significant differences in relative leaf water content among the hybrids. The hybrids 296A × ICSV 1502-1 (80.33%) recorded significantly higher relative leaf water content followed by 3060A × RSSV 260 (80%) and PMS 42A × RSSV 522 (79.67%). The lowest relative water content was observed in IIMR15A×RSSV 522 (68%). followed by CHS22 SS (68.67%). Gupta *et al*., (2000) [8] also reported that, the greater reduction in osmotic potential probably helps the genotypes in maintaining their RWC under stress condition.

3.3.2 Stay green score (1 to 9)

The data on stay green is presented in Table 6. The observations of genotypes AKMS 30A × AKSV 472R (Scale 3.07), AKMS 90 × SSV 74 (scale-3.07), IIMR 15A × 11 NRL (3.13) and AKMS 30A × RSSV 522 (scale 3.20) showed green leaf up to harvest stage, continuously. However, the genotype AKMS 90A × I-7 (scale 7) and PMS-71A × 11 NRL (scale-7.13) showed yellow green dry leaves at the harvest stage. Stay-green sorghum plants exhibit greener leaves and stem during the grain-filling period under water-limited condition as compared with their senescence counterparts, resulting in increased grain yield, grain mass, and lodging resistance, similar results were reported by (Borrell *et al*. 2014) [7].

3.3.3 Relative rate of leaf senescence

The data of relative rate of leaf senescence presented in table 7 the hybrid RMS 10A x SSR 7 show significantly high rate of leaf senescence (2.40%), followed by AKMS 90A x I- 7 (2.30%). The genotype AKMS 30A x AKSV 472R show slow rate of leaf senescence (1.46%). The rate of leaf senescence calculated on the basis of loss of leaf surface area per day, stay green colour scale show positive relation with the rate of leaf senescence. The hybrid RMS 10A × SSR 7 which was at par with the genotype PMS- 71A × 11 NRL (2.23%). similar results were reported (Borrell *et al*., 2014) [7].

Table 5: Relative water content (%) as influenced by sweet sorghum hybrid

Genotype	RWC at 50% flowering	RWC at 25 days after flowering
AKMS 30A x RSSV 522	78.33	71.33
AKMS 30A x 11 NRL	74.33	69.33
AKMS 30A x AKSV 472R	79.67	72.67
AKMS 90A x RSSV 522	79.33	70.00
AKMS 90A x AKSV 472R	79.33	71.33
AKMS 90A x SSV 74	82.67	79.33
AKMS 90A x I-7	80.33	75.67
PMS 42A x RSSV 522	85.67	79.67
PMS- 71A x AKSV 473R	77.00	71.33
PMS- 71A x11 NRL	76.67	70.67
RMS 10A x SSR 7	77.33	70.00
IIMR 28A x ICSV 18002	77.33	69.33
IIMR 33A x ICSV 17472	77.67	67.67
IIMR 35A x ICSV 17472	74.33	70.33
473A x ICSV 1502-1	81.33	71.00
473A x RSSV 522	84.67	79.00
2297A x RSSV 260	74.00	65.33
3060A x RSSV 260	86.33	80.00
3060A x11NRL	79.33	69.00
8914A x ICSV 17335	75.33	72.33
8914A x RSSV 589	83.00	75.67
8914A x RSSV 260	77.67	71.33
IIMR 13A x RSSV 589	78.33	70.67
IIMR 15A x RSSV589	78.67	69.67
IIMR 15A x RSSV 542	76.67	68.00
IIMR 15A x RSSV 522	72.33	68.00
IIMR 15A x 11NRL	82.33	77.00
3026A x RSSV 466	80.67	79.33
296A x ICSV 1502-1	86.67	80.33
ICSA 38 x SPV 2074	78.00	71.00
185A x 11 NRL	76.00	67.00
CSH 22 SS (check)	74.00	68.67
GM	79.05	72.28
S.E. m. ±	2.91	2.69
C.D. at 5%	8.32	7.72
C.V. %	6.37	6.46

3.2.4 SCMR value at 50%flowering

The data of SCMR value presented in table 6. the hybrid IIMR 15A x RSSV 589 recorded significantly highest (SCMR value 60) which is at par with the hybrid PMS-71A x AKSV 473R and IIMR 35A x ICSV 17472 (SCMR value 54). The hybrid IIMR 15A x RSSV 542 recorded significantly lowest SCMR value as compare to another hybrid genotype. Similar result reported by Komal, (2020) [12].

3.3.5 SCMR value at 25 days after flowering

The data of SCMR value at 25 days after flowering ranged from 40.00 to 54.33 with mean of (46.86). The hybrid 3026A x RSSV 466 recorded significantly highest SCMR value (54.33) than other hybrid, which was at par with the hybrid AKMS 90A x SSV 74 and PMS- 71A x AKSV 473R (46 SCMR value). The genotype 473A x RSSV 522 recorded significantly lowest SCMR value than the rest of genotype. Komal, (2020) [12] A field experiment was conducted at the research farm of Lovely Professional University, Punjab found that the chlorophyll content decreases after the 50% flowering to 25 days after flowering. Kashiwagi *et al.* (2010) [11] also reported that the similar result of SCMR value in sorghum genotype.

3.4 Leaf, stem panicle and total dry matter

3.4.1 Leaf dry matter (g/plant)

The data on leaf dry mean leaf dry matter is presented in table 7. The mean leaf dry matter at physiological maturity ranged between 23.33 to 32.00 g with a mean of 27.98 g/plant. The hybrid IIMR 15A × RSSV 589 recorded significantly highest mean leaf dry matter per plant (32.00 g), which was at par with 8914A × ICSV 17335 and 3060A ×11NRL. The hybrid IIMR13A x RSS V589 recorded significantly lowest leaf dry matter per plant (23.33g), followed by genotype PMS- 71A×11NRL (23.67g) The decline in leaf dry matter in all the genotypes might be due to senescence and leaf fall after drying. The more leaf dry matter accumulated in the hybrid might be due to its attributed the more leaf number, larger size and more thickness of leaves. These results found in support with the findings of Babu and Reddy (1971) [5].

3.4.2 Mean stem dry matter (g/plant)

The data on mean stem dry weight is presented in table 7. The data revealed that stem dry matter per plant increased up to 90 DAS and showed a slight decrease at harvest. The differences in stem dry weight of the hybrids were found significant at all stages.

The stem dry weight was significantly higher in AKM 90A × AKSV 472R (155.67 g) followed by 473A x RSSV 522 (150.00 g). The lowest stem dry weight was observed in AKMS 30A x AKSV 472R and IIMR 15A x RSSV 589 (111.67 g). The mean stem (excluding panicle) dry matter per plant increased up to 90 DAS and slightly decreased at harvest, in all the hybrids. The decrease in stem dry matter at harvest may be due to the translocation of assimilates from stem to developing grains. The stem dry matter conclusion found in support with the findings of Babu and Reddy (1971) [5].

3.4.3 Mean panicle dry matter (g/plant)

The data on mean panicle dry matter (g/plant) is presented in table 7. The mean dry matter of panicle at maturity varied from 49.67 to 67.33 g with a mean of (57.15 g.) The hybrid 8914A x ICSV 17335 recorded significantly the highest mean dry matter of panicle (67.33 g) which was at par with AKMS 90A×RSSV522 and 3026A×RSSV 466. The genotype IIMR 33A × ICSV 17472 recorded significantly lowest panicle dry matter (49.67 g). Fallowed by IIMR 35A × ICSV 17472 (50.00 g). Tolk and Schwartz (2017) [22] also reported the similar result of panicle dry matter per plant.

3.4.4 Total plant dry matter (g/plant)

The data on mean total plant dry weight is presented in table 7. The data revealed that total dry matter per plant increased continuously up to harvest. The differences in total plant dry weight of the genotypes were found significant at all stages. The total plant dry weight was significantly higher in AKMS 90A x AKSV 472R (244.33 g), followed by 8914A x ICSV 17335 (137.68 g), lowest total dry matter dry weight was observed hybrid 8914A x RSSV 589 (187.00 g).

Table 6: Relative rate of Leaf senescence, stay green score, SCMR value at 50% flowering and at 25 days after flowering as influenced by sweet sorghum hybrid

Genotypes	Relative rate of leaf senescence	Saty green colour score. (1 to 9 score)	SCMR value at 50% flowering	SCMR value at 25 days after flowering
AKMS 30A x RSSV 522	1.67	3.20	56.00	49.00
AKMS 30A x 11 NRL	1.70	3.50	56.33	48.33
AKMS 30A x AKSV 472R	1.46	3.07	58.33	50.67
AKMS 90A x RSSV 522	1.79	3.23	54.67	48.67
AKMS 90A x AKSV 472R	1.46	3.07	50.67	43.00
AKMS 90A x SSV 74	1.53	3.23	52.00	46.00
AKMS 90A x I-7	2.30	7.00	46.00	42.33
PMS 42A x RSSV 522	1.76	5.43	53.33	47.33
PMS- 71A x AKSV 473R	1.55	5.67	54.67	46.67
PMS- 71A x 11 NRL	2.23	7.13	48.67	43.33
RMS 10A x SSR 7	2.40	6.53	47.33	43.33
IIMR 28A x ICSV 18002	1.70	4.80	56.67	50.33
IIMR 33A x ICSV 17472	1.77	5.83	55.33	49.67
IIMR 35A x ICSV 17472	1.86	5.73	54.00	49.33
473A x ICSV 1502-1	1.84	5.63	51.00	45.67
473A x RSSV 522	2.08	6.53	42.67	40.00
2297A x RSSV 260	1.71	3.43	53.33	48.00
3060A x RSSV 260	1.67	3.40	51.67	46.33
3060A x11NRL	2.08	6.47	49.67	44.50
8914A x ICSV 17335	1.73	5.10	57.00	52.00
8914A x RSSV 589	1.99	6.27	46.33	42.33
8914A x RSSV 260	1.93	6.07	47.00	41.67
IIMR 13A x RSSV 589	1.70	5.30	57.00	50.00
IIMR 15A x RSSV589	1.65	3.40	60.00	50.67
IIMR 15A x RSSV 542	1.66	3.40	43.67	41.00
IIMR 15A x RSSV 522	1.76	5.63	48.67	42.67
IIMR 15A x 11NRL	1.66	3.13	56.33	48.67
3026A x RSSV 466	1.69	5.13	56.67	54.33
296A x ICSV 1502-1	1.84	5.67	45.67	41.67
ICSA 38 x SPV 2074	1.87	5.76	48.33	41.00
185A x 11 NRL	1.84	5.32	56.00	50.33
CSH 22 SS (check)	1.78	5.77	53.67	50.67
GM	1.81	4.90	52.52	46.86
S. E m. ±	0.08	0.22	2.12	0.49
C.D. at 5%	0.23	0.62	6.08	1.5
C.V. %	7.7	7.66	7	8.3

Table 7: Leaf, stem, panicle and total dry matter per plant as influenced by sweet sorghum hybrid

Genotypes	Leaf dry matter (g/plant)	Stem dry matter (g/plant)	Panicle dry matter (g/plant)	Total dry matter(g/plant)
AKMS 30A x RSSV 522	27.00	131.67	53	211.67
AKMS 30A x 11 NRL	31.33	118.67	54.33	204.67
AKMS 30A x AKSV 472R	31.67	111.67	57	200.33
AKMS 90A x RSSV 522	28.00	137.67	61	226.67
AKMS 90A x AKSV 472R	23.67	155.67	65	244.33
AKMS 90A x SSV 74	31.00	137.67	65.67	236.33
AKMS 90A x I-7	27.67	142.67	56.33	228.67
PMS 42A x RSSV 522	31.67	127.67	56.67	216.33
PMS- 71A x AKSV473R	25.67	131.67	54	212.00
PMS- 71A x 11 NRL	23.67	125.67	50.67	200.33
RMS 10A x SSR 7	31.00	129.67	54.67	215.67
IIMR 28A x ICSV 18002	26.33	120.67	66	213.00
IIMR 33A x ICSV17472	25.33	135.67	49.67	211.00
IIMR 35A x ICSV17472	24.00	137.67	50	211.67
473A x ICSV 1502-1	31.67	130.67	53	215.33
473A x RSSV 522	27.33	150.67	57.33	235.67
2297A x RSSV 260	27.00	144.67	56	227.67
3060A x RSSV 260	25.67	123.67	57	206.33
3060A x 11NRL	30.33	121.67	58.33	210.67
8914A x ICSV 17335	29.67	142.00	67.33	237.67
8914A x RSSV 589	23.33	112.67	50.67	187.00
8914A x RSSV 260	30.00	128.67	56.33	215.33
IIMR 13A x RSSV 589	23.33	129.67	56.67	210.00
IIMR 15A x RSSV589	32.00	111.67	54.67	198.67
IIMR 15A x RSSV 542	30.00	107.67	56	193.67
IIMR 15A x RSSV 522	26.00	119.67	59	205.00
IIMR 15A x 11 NRL	31.67	127.67	61	225.33
3026A x RSSV 466	25.33	133.67	65.67	220.00
296A x ICSV 1502-1	27.67	144.67	55.67	228.33
ICSA 38 x SPV 2074	25.33	131.67	57.33	214.67
185A x 11 NRL	30.00	130.67	57	217.67
CSH 22 SS (check)	25.67	123.00	55.67	204.67
GM	27.98	132.88	57.15	218.30
S.E m. ±	1.08	5.52	2.04	8.90
C.D. at 5%	3.10	15.82	5.84	25.49

4. Conclusions

In case of plant height significantly highest plant height at physiological maturity was recorded in hybrid IIMR 35A × ICSV 17472 (339.00 cm) and superior over rest of the genotypes. Lowest plant height was observed in hybrid 473A × ICSV 1502-1 (264.67 cm). Number of days required for 50% flowering was significantly influenced by various hybrids at flowering stage highest number of days required for 50% flowering was recorded in hybrid PMS 71A × AKSV 473R (94.00 days) which is followed by 3060A × RSSV 260 (93.00 days), Significant and highest leaf area at 50% flowering was recorded in hybrid 2060A × RSSV 466 (66.6 dm^2) and found significantly superior over rest of the hybrid genotypes. Number of days required for physiological maturity influenced by various hybrid genotypes at maturity stage. Highest number of days required for physiological maturity was recorded in 3060A × 11 NRL (131.00 days) followed by PMS 71A × AKSV 473R (130.00 days) and highest leaf area index at 50% flowering was recorded in hybrid 3026A × RSSV 466 (3.66 cm^2/cm^2) and found significantly superior over rest of the hybrid genotypes. Maximum SLA and SLW in sweet sorghum were obtained at 50% flowering in hybrid RMS 10A × SSR7 (0.12 cm^2/mg) and hybrid IIMR 33A × ICSV 17472 (9.76 mg/cm^2) respectively. Total dry biomass was significantly influenced by various hybrid genotypes at physiological maturity, higher values was reported by hybrid AKMS 90A × AKSV 472A (244.33 g/plant) and 8914A × ICSV 17335 (237.67 g/plant). Overall, all the growth and yield contributing parameters like meliable cane yield and juice yield are observed better in hybrid AKMS 90A × I-7 and 2297A × RSSV 260. However, maximum harvest index was observed in genotype IIMR 15A × 11 NRL (10.23%). In case of number of grains per primary significantly highest number of grains was recorded in hybrid 2297A × RSSV 260 and found significantly superior over rest of the genotypes. No. of grains per earhead numerically influenced by various genotypes. Highest no. of grains per earhead was recorded in the genotype AKMS 90A × SSV 74 and found significantly superior over rest of the hybrid genotype. Stay green score significantly influenced by various genotypes at physiological maturity stage, Highest stay green score at physiological maturity was recorded in hybrid PMS 71A ×11 NRL that showed yellow green dry leaves at physiological maturity. The hybrid AKMS 30 A × AKSV 472 and AKMS 90A × SSV 74 (scale 3.07) shown green leaf at harvest stage. Total fresh biomass was influenced by various genotypes at physiological maturity, higher values were reported by hybrid 8914A × RSSV 589 (18.99 kg/plot). The hybrid PMS 42A × RSSV 522 (15.03 kg/plot) recorded lowest mean total fresh biomass.

5. References

1. Addai IK, Alimiyawo M. Graphical determination of leaf area index and its relationship with growth and

yield parameters of Sorghum (*Sorghum bicolor* L. Moench) as affected by fertilizer application. Journal of Agronomy. 2015;14(4):272.
2. Anonymous. Area, production and productivity of sorghum in India. Ministry of Agriculture, Government of India; c2019. Available from: http.fao.org/foodstat/collection
3. Anonymous. Area, production and productivity of sorghum in India. Ministry of Agriculture, Government of India; c2019.
4. Ashley DA, Doss BD, Bennett OL. Relation of Cotton Leaf Area Index to Plant Growth and Fruiting 1. Agronomy Journal. 1963;57(1):61-64.
5. Babu AR, Reddy PR. Rate of dry matter production in different plant parts at various stages of growth in sorghum; c1971.
6. Barrs DN. Weatherly PE. Re-examination of relative turgidity for estimating water deficits in leaves. Australian Journal of Biological Sciences. 1962;15:413-428.
7. Borrell AK, Mullet JE, George-Jaeggli B, van Oesterom EJ, Hammer GL, Klein PE, *et al*. Drought adaptation of stay-green sorghum is associated with canopy development, leaf anatomy, root growth, and water uptake. Journal of Experimental Botany. 2014;65(21):6251-6263.
8. Gupta SC, Rathore AK, Sharma SN, Saini RS. Response of chickpea cultivars to water stress. Indian Journal of Plant Physiology. 2000;5(3):274-276.
9. Hoel BO, Solhaug KA. Effect of irradiance on chlorophyll estimation with the Minolta SPAD-502 leaf chlorophyll meter. Annals of Botany. 1998;82(3):389-392.
10. Kadam GN, Gadakh SR, Awari VR. Physiological analysis of Rabi sorghum genotypes for shallow soil. Journal of Maharashtra Agricultural Universities (India).
11. Kashiwagi J, Upadhyaya HD, Krishnamurthy L. Significance and genetic diversity of SPAD chlorophyll meter reading in chickpea germplasm in the semi-arid environments. Journal of Food Legumes. 2010;23(2):99-105.
12. Komal AS. Evaluation of Sweet Sorghum Genotypes for Plant Height, Chlorophyll and Nitrogen Content under Late Sown Conditions. European Journal of Molecular & Clinical Medicine. 2020;7(07):2020.
13. Landberg K. Leaf weight per area and leaf size of 85 Estonian woody species in relation to shade tolerance and light availability. Forest Ecology and Management. 1990;70(1-3):1-10.
14. Mokariya LK, Malam KV. Sweet Sorghum: A Smart, Multipurpose Crop. Agronomy.com. 2020;61.
15. Meena RS, Singh D, Jat BL. Response of single-cut fodder sorghum genotypes to fertility levels under rainfed conditions of Rajasthan. International Journal of Agricultural Engineering. 2017;10(2):423-440.
16. Mutkule BR. Physiological studies on sweet stalk sorghum genotypes in relation to phenology as influenced by temperature and photoperiod. M.Sc. (Agri) Thesis. M.P.K.V., Rahuri, India; c2010.
17. Nakamura S, Nakajima N, Nitta Y, Goto Y. Analysis of successive internode growth in sweet sorghum using leaf number as a plant age indicator. Plant Production Science. 2011;14(4):299-306.
18. Nirmal SV, Shinde MS, Awari VR, Patil VR, Gadakh SR, Dalvi US, *et al*. RSSV-313: A sweet sorghum donor for high biomass. International Journal of Current Microbiology and Applied Sciences. 2017;6(3):907-912.
19. Sathe BV, Salunke VD, Deshmukh RV. Dry matter accumulation and its partitioning trends in sorghum hybrids and varieties. Annals of Plant Physiology. 1997;11:104-106.
20. Shinde MS, Narkhede BN, Patil SP. Association of physiological parameters with grain yield of rabi sorghum. Annals of Plant Physiology. 1998;12(1):65-66.
21. Stickler FC, Pauli AW. Leaf Removal in Grain Sorghum. I. Effects of Certain Defoliation Treatments on Yield and Components of Yield 1. Agronomy Journal. 1961;53(2):99-102.
22. Tolk JA, Schwartz RC. Do more seeds per panicle improve grain sorghum yield. Crop Science. 2017;57(1):490-496.
23. Norem H, Irgens F, Schieldrop B. A continuum model for calculating snow avalanche velocities. IAHS Publ. 1987;162:363-379.