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Physio-biochemical assessment of advanced breeding lines of *rabi* sorghum under depleting soil moisture

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Abstract
An experiment was conducted to evaluate the effects of depleting moisture on physio-biochemical and yield parameters on sorghum genotypes during *rabi* season. The trail consists 16 genotypes with single moisture regimes up to harvest. The study revealed that genotypes RSV-1910, RSV-2520 and RSV-2511 were performed superiorly under the depleting soil moisture condition by maintaining higher number of leaves, leaf area, LAI, RLWC, photosynthetic rate, PAR, harvest index (%). Therefore, these drought tolerant donors could be used as parents in breeding programme for developing drought tolerant genotypes in sorghum.

Keywords: Sorghum, soil moisture, Physio-biochemical and yield parameters

Introduction
Sorghum is a major staple crop for the world's poorest and most vulnerable people. Sorghum, an outstanding crop in our country's dry and semi-arid regions continues to give livelihood security to small and marginal farmers forced to farm in rainfed environments defined by water scarcity and periodic droughts. Sorghum has a wide range of adaptability and can be grown in wide series of environments. It is mainly grown for food, feed, fuel and industrial purposes. Combined with its potential use in the emerging biofuels industry, sorghum is an ideal candidate for a more concerned crop improvement program as agriculture is to push more marginal lands, food and energy demands might be boosted in the near future. Sorghum has an ability to cope with many types of stresses, including heat, drought and salinity.
Sorghum (also known as jowar) is the world's fifth most important cereal food crop. The grains are also utilized in chicken feed and other industrial applications such as the manufacturing of drinkable alcohol. It is member of the Poaceae family. It is one of the most energy efficient crops for producing food and biomass using solar energy and water. Drought tolerance is inbuilt in the crop and it can be cultivated in a wide range of conditions. Sorghum is one of the truly necessary crops for human survival due to its vast range of uses and adaptation.
Water stress is a major limitation to crop productivity worldwide and possible global climate change scenarios suggest a future increase in the risk of drought. Water stress has diverse effects on yield depending on the development stage at which it occurs.
The biggest sorghum producers include the United States, India, Mexico, Nigeria, Sudan and Ethiopia. Drought moisture stress causes, abiotic stress that impact crop growth and development at critical phases. Depending on the frequency and intensity of moisture stress farmers suffer significant losses. The scarcity of cultivars adapted to various soil types, as well as the occurrence of stress during the reproductive stage are the main causes of *rabi* sorghums low output. The study of growth and physiological features aids in determining why genotypes differ in their productivity. India accounts for 70 per cent of area under sorghum out of that *rabi* sorghum occupies major share near about 60 per cent.
The productivity of sorghum in India is still considered to be low at 849 kg/ha compared to the average global productivity of 1,444 kg/ha (FAOSTAT, 2019) [6]. Low productivity is attributed to marginal soils, unpredictable rainfall, insect pests and diseases, and negligence in management. The water deficit is increased due to erratic rainfall distribution exacerbated by climate change (Eggen *et al.*, 2019; Ocheing *et al.*, 2020) [5, 14].
The global challenge for the next few decades will be to boost food production while using less water. As a result, genetic improvements in plant creates important role in abiotic stress adoption.

Rabi sorghum is a distinctive and prominent element of dryland situations, as it grows on receding soil moisture at varied soil depths is one of the key restrictions limiting yield potential. With these limits in mind, its critical to screen the many advanced breeding lines for moisture stress tolerance as part of the *rabi* sorghum improvement. Therefore, the present investigation was conducted under rainout shelter during *rabi* 2020-21.

Materials and Methods

The present investigation was conducted at Sorghum Improvement project, Mahatma Phule Krishi Vidyapeeth (MPKV) Rahuri, District Ahmednagar, Maharashtra, India. The seeds were obtained from Sorghum Improvement Project, MPKV, Rahuri. The soil of experiment field was medium black type with bulk density of 1.3. The moisture content at field capacity and permanent wilting point were 34.40 and 21.66%, respectively. The field experiment was laid out in a Randomized Blok Design (RBD) with two replications in field condition.

The Plant height (cm) of five randomly selected plants from each plot was recorded at maturity in cm by measuring from the ground base of the plant up to the panicle. The Number of green leaves per plant (more than 50% green portion) was counted at 60 days. The leaf area of the plant was calculated at 90 days 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) [23]. The stage panicle initiation was considered as described by Lee *et al.*, (1974) [9]. The number of days required from sowing to 50% flowering was recorded after opening of flowers as characterized by the profusion of anthers outside the spikelets. The physiological maturity was identified after the appearance of black spot on hylum of seed. The relative leaf water content (%) was determined at flowering stage as per the following formula.

$$\text{RLWC (\%)} = \frac{\text{Fresh weight (Wf) - Dry Weight (Wd)}}{\text{Turgid weight (Wt) - Dry Weight (Wd)}} \times 100$$

The chlorophyll stability index was computed by using the methodology given by Dhopte and Livera (1989) at flowering stage. Proline content in leaf tissues of stress sorghum at 50% flowering was determined using the acid ninhydrin reagent as per the method described by Bates *et al.*, (1973) [2]. The physiological parameters *viz.*, photosynthetic rate, stomatal conductance, transpiration rate and PAR (Photosynthetically Active Radiation) were determined from fully expanded leaf by using portable IRGA (Infra Red Gas Analyzer, Model LI-6400, LiCOR) at 50% flowering between10.00 am to12.00 noon.

The grain yield per plant was sun dried before weighing and average grain weight per plant was recorded. Thousand grains of each genotype were counted and weight (g) was recorded by electronic balance. The harvest index (%) was calculated by using the formula at given by Donald (1962) [4].

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (g/plant)}}{\text{Biological yield (g/plant)}} \times 100$$

The correlation studies was worked out between morpho-physiological traits with grain yield as per the formulae suggested by Snedecor and Chochran (1967).

$$r = \frac{\Sigma (X_1 - \bar{X}) (X_2 - \bar{X}_2)}{[\Sigma (X_1 - \bar{X}_1)^2] [\Sigma (X_2 - \bar{X}_2)^2]}$$

Where,

X_1 and X_2 are the means of characters one and two respectively.

The significance of correlation coefficient was tested against "r" values given by Fisher and Yates (1963) [7] at (n-2) degrees of freedom at 5 and 1 per cent level of significance.

Results and Discussion

The moisture status of experimental soil was recorded at different growth phases and soil depth at 0-15, 15-30, 30-45 and 45-60 cm. The soil moisture data was depicted in Table 1. The gradually decrease in soil moisture was observed from sowing up to the harvest of crop.

Table 1: Soil moisture status (%) during crop growth period

Sr. No.	Growth phases	Soil depth (cm)			
		0-15 cm	15-30 cm	30-45 cm	45-60 cm
1	At sowing	37.7	38.6	39.3	40.9
2	At panicle initiation	30.4	32.0	33.0	35.2
3	At 50% flowering	25.6	27.7	29.8	31.4
4	At physiological maturity	20.4	21.7	25.0	27.6

The soil moisture exhaustion was very less at early vegetative phase. During the reproductive phase, the plants demand more water to fulfill the crop evapo-transpiration. The plant roots extracted more water from all the depths. Nagargoje, (2017) [10], Shinde *et al.*, (2017) [17] and Devare, (2019) [3] reported the similar results earlier. The increase in water use at reproductive phase as compared to vegetative phase could be due to increase in crop water demand during this phase to fulfill for which root extracted more and more water from all the depth.

Plant height (cm): Growth is an effect of metabolic activities of the plant when anabolic processes are more than catabolic processes. Plant height is a genetically controlled character and varies from time to time and genotype to genotype. The variation was ranged from 180.50 cm to 291.80, with a mean of 231.86 cm, at maturity. The highest mean plant height was noticed by RSV-1910 (291.80 cm) except RSV-2408, RSV-2511 and RSV-2520. Significantly the lowest plant height was noticed in the genotype RSV-1440 (180.50 cm) except the genotype RSLG-2419, RSV-2430, RSV-2509, RSV-2519 and RSV-1988. Under the residual soil moisture during *rabi* season, the reduction in plant height in sorghum genotypes could be attributed to decrease in cell division and its elongation under moisture stress. The significant variations in plant height among the *rabi* sorghum genotypes was reported by Nagargoje, (2017) [10] and Shinde *et al.*, (2017) [17].

Number of green leaves plant^{-1}: A varietal character of sorghum is determined by the number of leaves plant^{-1} where each node produces a single leaf. From our records at 60 DAS, the number of green leaves plant^{-1} ranged from 5.09 to 8.75 with a mean of 6.89. Significantly the highest mean number of green leaves was recorded by the genotype RSV-2520 except RSV-2408, RSV-2513, RSV-1910 and P. Suchitra, while the genotype RSV-2519 recorded significantly the lowest mean number of leaves plant^{-1} (5.09) except RSLG-2419, RSV-2463 and RSV-1440. Significant differences in number of leaves were observed in all tested *rabi* genotypes. As the plant leads to maturity, the earlier formed leaves were senesced first and may result in significant decrease at this stage. Andhale (2014) [1], Nagargoje (2017) [10] and Devare (2019) [3] recorded the similar results during their study.

Leaf Area (dm^2) plant^{-1}: Leaf area is one of the important morphological characters of plant on which decide the final performance of plant. Leaf area per plants depends upon the number of leaves, rate of expansion, size of leaves and senescence. The leaf area ranged from 15.71 dm^2 to 25.47 dm^2 with a mean of 19.89 dm^2 at 90 days after sowing. The genotype RSV-2511 (25.47 dm^2) produced the significantly highest mean leaf area plant^{-1} except RSV-2520 and RSV-1910.The genotype RSV-2517 (15.71 dm^2) exhibited significantly the lowest mean leaf area plant^{-1} except RSV-2430 and RSV-2519. Similar results were recorded by Nirmal *et al.*, (2016) [12] and Nagargoje (2017) [10].

Number of days for Panicle initiation: Panicle initiation is the start of reproductive phase of sorghum development. It is when the actual panicle or head begins to form in the base of the stem, just above the soil surface. The study shows the variation among the genotypes from 33 to 46.66 days with a mean of 38.40 days. The significantly maximum mean number of days (46.66) for panicle initiation was reported by the genotype RSV-2513 except RSV-2430, RSV-1440 and RSV-1910. The significantly minimum mean number of days (33) to panicle initiation was noticed in genotype RSV-2509 which was at par with RSV-2463, RSV-2505, RSV-1988 and RSV-2519. The findings matches with Shinde *et al.*, (2003) [20], Andhale (2014) [1], Nagargoje (2017) [10] and Devare (2019) [3].

Number of days to 50% flowering: The flowering induction is one of the most challenging phenomenon in crops and is governed by the photoperiod. The days to initiation of panicle associates with the variations in days to 50% flowering in *rabi* sorghum genotypes. The genotypes under study, showed the variation in 50% flowering which was ranged between 70.50 to 87 days with a mean of 77.94 days. The significantly maximum mean numbers of days (87) were required for the genotype RSV-1440 for 50% flowering which was at par with RSLG-2419, RSV-*2*463, RSV-*2*513. The significantly minimum number of days (70.50) for 50% flowering was noticed in genotype RSV-2520 except RSV-2511, P. Suchitra and P. Anuradha. Andhale (2014) [1], Pawar (2018) [16] and Devare (2019) [3] reported similar type of variation in 50% flowering in *rabi* sorghum genotypes.

Number of days for Physiological Maturity: Physiological maturity coincides with maximum dry weight of the seed and is marked by the formation of black spot on hylum of sorghum seed. The number of days reported for physiological maturity showed the variation from 112.50 to 128.50 with a mean of 120.16 days. The genotype RSV-1440 recorded significantly the highest mean number of days (128.50) for physiological maturity except the genotypes RSLG-2419, RSV-*2*463, RSV-*2*513 and RSV-2463. The significantly minimum number of days for physiological maturity (112.50) was taken by the genotype RSV-2520 which was at par with RSV-2505, RSV-2509, RSV-2511 and RSV-2519. The fluctuations in environmental factors such as temperature, photoperiod and relative humidity results in differences in panicle initiation and 50% flowering which finally resulted in to differences in physiological maturity. Similar results were also reported by Nirmal *et al.*, (2015) [13], Nagargoje (2017) [10] and Devare (2019) [3].

Relative Leaf Water Content (%): The Relative leaf water content under stress denotes the ability of crop to tolerate moisture stress. The RLWC ranged from 68.04 to 86.30 per cent with a mean of 78.58 per cent. The significantly maximum relative leaf water content (86.30%) was observed in genotype RSV-*2*511 at 50% flowering stage except RSV-2408, RSV-1910, RSV-2513, P. Suchitra, P. Anuradha and RSV-2520. The significantly minimum relative leaf water content at 50% flowering stage (68.04%) was recorded by the genotype RSV-2519 except the genotypes RSV-2509, RSV-2517 and RSV-1440. The maximum RLWC and minimum excised leaf water loss are associated with the moisture stress resistance and these parameters are valuable indicators of plant water status. The moisture stress causes the water loss within the plant and reduced the RLWC. The various metabolic activities in leaf tissue can be judged by measuring RLWC and this can be considered as integral measure of plant water status. The present findings were in accordance with the findings of Gadakh *et al.* (2013) [8] and Shinde *et al.* (2016) [19].

Chlorophyll Stability Index (%): The capability of genotypes to grow well under moisture stress can be evaluated by estimating CSI. The chlorophyll stability index is inversely proportional to the drought tolerance and ranged from 0.21 to 0.32 per cent with an average of 0.25 per cent. The significantly highest chlorophyll stability index (0.32%) was reported by genotype RSV-2519 at 50% flowering except RSV-2430. The significantly lowest chlorophyll stability index at 50% flowering (0.21%) was observed in genotypes RSV-2511, RSV-2408 and P. Anuradha which was at par with RSV-*2*520, P. Suchitra, RSV-1988 and RSV-1910. Similar results were also reported by Shinde *et al.*, (2011) [18] and Nagargoje (2017) [10].

Proline Content (µ moles g^{-1} fw): The proline content in non-stress (control) condition ranged from 8.37 to 18.18 µ moles g^{-1} fw with mean of 11.92 µ moles g^{-1} fw. The genotype RSV-2430 recorded significantly the highest mean proline content (18.18 µ moles g^{-1} fw) except RSV-1988. The significantly lowest mean proline content (8.37 µ moles g^{-1} fw) was recorded by genotype P. Anuradha which except genotypes RSV-*2*505, RSV-2519 and RSV-2513 at non-stress condition.

The proline content in stress condition ranged from 10.89 to 24.74 µ moles g^{-1} fw with mean of 18.36 µ moles g^{-1} fw. The genotype RSV-1910 accumulated significantly the highest proline content (26.03 µ moles g^{-1} fw) except RSV-*2*430 and RSV-2520. The genotype RSV-1440 recorded significantly the lowest proline content (µ moles g^{-1} fw) which was at par with RSV-2519 and P. Anuradha. The percentage of proline content under stress condition increase over control ranged from 30.42 to 81.02 per cent. *rabi* sorghum genotype RSV-1910 showed highest (%) increase over control in proline content with 81.02 per cent followed by RSV-2408 with 70.27 per cent. The *rabi* sorghum genotypes which have higher proline content might increase the synthesis ability of osmotic regulation for protection from the cell damage.

Osmoregulation is primary adaptation response because it is directly concerned with the maintaining the structure of the enzymes and removal of reactive oxygen species. The optimum growth and development of plant under moisture stress condition is possible if, proper cell turgidity is maintained. Increase of proline causes the mediation of osmotic adjustment and thus, the plant will keep growing under drought stress, since proline has hydrophilic property it might replace water molecules around nucleic acid, protein and membrane during water shortage. Osmoregulation has been known to be associated with maintenance of leaf area; water extraction due to root growth, continued photosynthesis and translocation of assimilates from source to sink. The data (Table 1 & 2) on leaf proline revealed the significant difference among the tested genotypes. A positive correlation was observed between grain yield and proline accumulation (r=0.816**). These results were in line with results observed by Patil *et al.* (2016) [15].

Mean grain yield plant^{-1} (g): The grain yield plant^{-1} is an end product of different closely interlinked metabolic processes of the plant. The variation in grain yield plant^{-1} was ranged from 35.84 to 99.29 g with a average of 66.35 g. Significantly the highest grain yield plant^{-1} (99.29 g) was produced by the genotype RSV-1910 except RSV-2520, RSV-2408 and P. Suchitra, while the genotype RSV-2519 recorded significantly lowest grain yield plant^{-1} (35.84 g) except RSV-2430, RSV-2509 and RSV-1440. The variation in yield attributing traits *viz.*, thousand grain weight and harvest index (Table 4) were noticed in present investigation which contributed significant variation in grain yield plant^{-1}. These conclusions are in accordance with Andhale (2014) [1], Nirmal *et al.* (2015) [13], Nagargoje (2017) [10] and Devare (2019) [3] who reported the similar results.

Thousand Grain Weight (g): Thousand seed weight is important yield contributing parameter which has direct effect on the grain yield. The thousand grain weight of tested genotypes was ranged from 27.04 to 38.30 g with a mean of 32.33 g. The genotype RSV-2520 recorded significantly the maximum thousand grain weight (38.30 g) except RSV-2408, RSV-2511 and RSV-1910. The minimum thousand grain weight (27.04 g) was recorded by the genotype RSV-2519 except the genotypes RSV-2430, RSV-2463, RSV-2463, RSV-2509 RSV-1440 and RSV-1988. The decrease in thousand grain weight under moisture stress in *rabi* sorghum might be due to lower and poor translocation of photosynthetes in the developing grains. The results are in consonance with Nirmal *et al.* (2015) [13], Nagargoje, (2017) [10] and Devare, (2019) [3].

Harvest Index (%): The harvest index is an indirect measure of grain yield and important indicator of photosynthets translocation for efficient conversion into the grain yield. The harvest index of tested *rabi* genotypes under study varied from 23.33 to 37.72 per cent with a mean of 29.36 per cent. The significantly highest harvest index (37.04%) was noticed in the genotype RSV-2408 except the genotypes RSV-1910, RSV-2520, RSV-2436, RSV-2511 and P. Suchitra while, the genotype RSV-2509 recorded the lowest harvest index (23.33%). Harvest index of RSV-2408, RSV-2511 and RSV-1910 was higher (37.04, 35.72 and 34.79% respectively) indicating the highest translocation efficiency of assimilates for grain yield. These findings were in accordance with Shinde *et al.*, (2008) [20], Andhale (2014) [1], Nagargoje (2017) [10] and Devare (2019) [3].

Correlation Studies: The correlation data revealed that, the grain yield was positively and strongly correlated with the traits like number of leaves (r=0.617*), leaf area (r=0.656*), RLWC (r=0.904**), photosynthetic rate (r=0.930**), PAR (r=0.933**), proline content (r=0.916**), grain number panicle^{-1} (r=0.983**) and harvest index (r=0.762*). The physiological parameters *viz.*, chlorophyll stability index (r=-0.643*), and transpiration rate (r=-0.567*) exhibited a strong and significantly negative correlation for the grain yield. Hence, for the developing drought sorghum tolerant genotypes these traits should be considered. Our findings are in agreement with the result reported by Sonawale (2008) [22] and Nirmal and Patil (2008) [11].

Table 2: Correlation coefficient between grain yield and physio-biochemical parameters of *rabi* sorghum genotypes.

Sr. No.	Parameters	
1.	Relative leaf water content	0.904**
2.	Chlorophyll stability index	-0.643*
3.	Photosynthetic rate	0.930**
4.	Staomatal conductance	0.453
5.	Transpiration rate	-0.567*
6.	Photosynthetically active radiation	0.933**
7.	Proline content	0.816**
8.	Grain numbers panicle^{-1}	0.983**
9.	Thousand grain weight	0.815*
10.	Harvest Index	0.762**

* Significant at 5% r= at 5%

** Significant at 1% r= at 1%

Table 3: Genotypic variation Physio-bio chemical studies

Sr. No	Genotypes	Plant height (cm) @maturity	No. of green leaves plant^{-1} @ 90 Days	Leaf area (dm^2) @ 90 days	Days to Panicle Initiation	Days to 50% flowering	Days to physiological maturity	RLWC (%) @ Flowering stage	Chlorophyll Stability Index (%) @ Flowering stage	Proline content (µ moles g^{-1} fw) @ Non Stress	Proline content (µ moles g^{-1} fw) @ Stress
1	RSLG-2419	216.89	5.91	19.59	42.78	85.50	128.00	78.49	0.25	10.55	15.96
2	RSV-2408	277.42	8.23	21.83	41.28	80.00	122.00	84.95	0.21	11.64	19.82
3	RSV-2430	195.84	6.06	18.27	42.89	78.50	126.50	73.63	0.29	18.18	24.74
4	RSV-2463	227.18	5.78	20.37	39.67	85.00	124.50	76.31	0.28	13.61	22.00
5	RSV-2505	236.06	6.73	21.55	34.00	73.50	115.50	78.75	0.27	11.15	17.85
6	RSV-2509	199.57	6.70	17.27	33.00	74.50	117.50	74.16	0.26	10.30	14.66
7	RSV-2511	278.54	7.23	25.47	34.74	74.50	115.00	86.30	0.21	11.19	17.82
8	RSV-2513	222.01	8.00	16.33	46.66	83.50	126.00	79.44	0.28	10.71	16.75
9	RSV-2517	240.10	6.31	15.71	40.00	76.50	119.00	71.38	0.26	10.33	14.94
10	RSV-2519	199.93	5.09	16.09	34.00	73.00	114.50	68.04	0.32	9.45	12.61
11	RSV-2520	261.11	8.75	22.76	33.68	70.50	112.50	85.01	0.22	13.90	23.06
12	RSV-1910	291.80	8.18	23.12	40.18	81.50	121.50	85.30	0.23	14.38	26.03
13	RSV-1440	180.50	5.84	19.30	42.60	87.00	128.50	73.17	0.23	8.35	10.89
14	RSV-1988	215.58	6.20	21.42	36.00	72.50	116.00	78.45	0.24	17.41	24.41
15	Phule Suchitra	238.65	8.13	20.51	38.00	76.50	119.00	82.72	0.23	11.17	18.23
16	Phule Anuradha	228.68	7.19	18.62	35.00	74.50	116.50	81.12	0.21	8.37	13.94
	Range	180.50-291.80	5.09-8.75	15.71-25.47	33-46.66	70.50-87	112-128.50	68.04-86.30	0.21-0.32	8.37-18.18	10.89-24.74
	Mean	231.86	6.89	19.89	38.40	77.94	120.16	78.58	0.25	11.92	18.36
	S.E.±	12.27	0.32	1.03	2.27	2.50	1.99	2.35	0.01	0.99	1.45
	CD at 5%	36.99	0.96	3.11	6.84	7.54	5.99	7.09	0.04	2.99	4.36

Table 4: Genotypic variation in yield studies

Sr. No	Genotypes	Proline content (µ moles g^{-1} fw) @ Increase over control	Photosynthetic rate (µmole CO_2m^{-2} s^{-1}) @ Flowering stage	Stomatal conductance (mole m^{-2} s^{-1}) @ Flowering stage	Transpiration rate (mole H_2Om^{-2} s^{-1}) @ Flowering stage	PAR (µ mole m^{-2} s^1) @ Flowering stage	Grain yield (g/plant)	Thousand grains weight (g)	Harvest index (%)
1	RSLG-2419	51.28	27.55	16.30	1.62	612.00	55.33	33.74	27.77
2	RSV-2408	70.27	32.98	19.26	1.38	758.35	92.03	37.87	37.04
3	RSV-2430	36.08	19.40	14.90	1.63	543.00	41.54	28.94	25.09
4	RSV-2463	61.65	30.40	16.30	1.60	637.00	68.51	29.83	30.64
5	RSV-2505	60.09	31.60	16.40	1.51	642.23	70.83	32.20	29.46
6	RSV-2509	42.33	23.80	13.20	1.66	587.01	46.58	30.47	23.33
7	RSV-2511	59.25	32.26	20.41	1.37	721.17	96.41	35.80	34.79
8	RSV-2513	56.40	29.40	15.30	1.61	628.00	66.48	31.98	30.72
9	RSV-2517	44.63	25.60	13.40	1.65	586.26	50.28	31.45	26.14
10	RSV-2519	33.44	15.60	11.47	1.66	521.00	35.84	27.04	23.49
11	RSV-2520	65.90	35.11	20.13	1.40	709.93	93.68	38.30	32.46
12	RSV-1910	81.02	34.20	18.32	1.35	738.45	99.29	34.86	35.72
13	RSV-1440	30.42	17.50	14.80	1.61	501.00	41.38	28.02	27.00
14	RSV-1988	40.21	20.90	14.40	1.50	567.00	43.68	30.14	25.14
15	Phule Suchitra	63.21	33.80	15.90	1.42	679.00	90.17	34.17	33.88
16	Phule Anuradha	66.55	32.91	17.10	1.40	695.00	81.36	32.46	31.93
	Range	-	15.60-35.11	13.20-20.41	1.35-1.66	501-758.35	35.84-99.29	27.04-38.30	23.33-37.72
	Mean	-	27.69	16.19	1.52	632.90	67.09	32.33	29.36
	S.E.±	-	1.68	1.18	0.04	38.15	3.97	1.25	1.97
	CD at 5%	-	5.06	3.57	0.13	114.99	11.42	3.76	5.94

Conclusion
It could be concluded that the genotypes RSV-1910, RSV-2520 and RSV-2511 were performed well under the reducing soil moisture condition compared to the rest of the genotypes, therefore these genotypes recommended for *rabi* season sowings with stressful or non-stressful conditions in semi-arid regions of India.

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