Original Research Article

Morpho-physiological evaluation of finger millet (*Eleusine coracana* L. Gaertn.) genotypes for drought tolerance

ABSTRACT

Finger millet (*Eleusine coracana* L. Gaertn.) is a nutritious and climate-resilient crop with a C_4 type carbon fixation pathway. The present study was aimed to assess the drought tolerance capacities of twenty short medium-late duration finger millet genotypes under water stress (WS) for 15 days during reproductive stage to identify the traits and genotypes for drought tolerance using statistical analysis. The shoot length (16.74 %), leaf area (28.21 %), shoot dry weight (30.20 %), relative water content (32.70 %), membrane stability index (37.53 %), test weight (14.64 %), grain yield (36.48 %) and straw yield (31.34 %) were decreased and found sensitive to water stress, but the root length (by 13.45 %), root to shoot ratio by length (36.15 %) and proline (146.96 %) were increased. From the present investigation, among the 20 genotypes tested, KMR-204 and GPU-45 in short duration, ML-365, PR-202 and GPU-28 in medium duration, KMR-301 and L-5 in long duration showed identical performance for maximum number of traits under consideration. Hence, our results provide inputs to the breeders to select genotypes as parents and to design effective strategies in crop improvement programs.

Keywords: Drought, root length, relative water content, membrane stability index, proline

1. INTRODUCTION

Finger millet (*Eleusine coracana* L.) called as ragi is the third important and extensively cultivated millet in India after sorghum and pearl millet. Its wider adaptability to diverse agro climatic and water deficit condition allowed its presence ubiquitously in diverse places. Superior nutritive index of finger millet both at whole plant level and in grains makes it better food source for human consumption and fodder for rumens. Among cereals, it is an important nutraceutical crop containing protein (6-13 %), fat (1.3 %), carbohydrates (72.0 %), highest quantity of calcium (352 mg 100 g-1), antioxidants, dietary fibers (18 %), minerals (2.5-3.5 %), phenolics (0.3-3 %) and amino acid (Leucine, 594 mg g^{-1} of protein) [1]. Now a day, demand for finger millet is gaining importance with increasing diabetic population [2].

It is a self-pollinated, allotetraploid crop with the genome composition of AABB with the chromosome number 2n=4x=36 and evolved from a cross between two diploid species, *Eleusine indica* (AA genome donor) and *Eleusine floccifoliaor E. tristachya* (BB genome donor) belongs to the family Poaceae and subfamily Chloridoidae[3] with C_4 NADME photosynthetic pathway [4]. It is a moderately productive crop that can thrive under a variety of harsh environmental conditions and generally grown on low fertility soils. The cultivated species also have several races and subraces and hence, it displays greater variability and diversity for most agronomically important traits. Under this scenario, finger millet has gained focus of scientific research for their extraordinary potential to grow under high temperature, low moisture and poor soils.

Most of the finger millet growing farmers consider finger millet as less valued and grown under rainfed conditions. Most of the popular varieties, under moisture stress situation showed a yield reduction up to 25-30 per cent [5]. Such a reduction in grain yield could be attributed to reduction in various physiological and yield attributing traits. Further, queries are being raised by the public for a drought tolerant variety of finger millet.

Feeding the fast growing human population with balanced nutritional diet under unpredictable severe weather events is a challenging task globally. The climate change crisis is expected to cause shifts in food production and yield loss, causing a severe threat to food security. A key strategy to adapt to a changing climate is to develop and promote elite gremplasms with stable yields that can survive under changing weather conditions [6]. There exist great potential in underutilized crops such as finger millet that are well adapted to extreme weather conditions and can acts as an alternative food resource towards ensuring food and nutritional security [7]. Despite the many advantages offered by the cultivation of finger millet, there is limited research on tolerance to drought in finger millet. The production of finger millet is restricted to low yielding and poorly adapted genotypes [8]. However, there is a great potential to increase production through screening and selection of well adapted genotypes to low soil moisture with better grain yield. Therefore, the present investigation was conducted to identify finger millet lines with enhanced tolerance to drought based on morpho-physiological traits with the intention to be used in future breeding programmes to develop improved drought tolerant cultivars.

2. MATERIAL AND METHODS

A field trail was conducted in College of Agriculture, Keladi Shivappa Nayaka University of Agricultural and Horticultural Sciences, Shivamogga,coming under Southern Transition Zone (Zone-7) of Karnataka. The geographical reference point of the experimental site is 13° 58' to 14° 1' North latitude and 75° 34' to 75° 42' East longitude during summer 2021 on sandy clay loam soil. The experimental material consisted of 20 finger millet genotypes collected from Seed unit, Zonal Agricultural Research Station, Mandya, India. These twenty top leading *viz*.,G_1: GPU-26, G_2: GPU-28, G_3: GPU-45, G_4:GPU-48, G_5: GPU-66, G_6:GPU-67, G_7: Indaf-5, G_8:Indaf-7, G_9:MR-1 G_{10}:MR-6 G_{11}:ML-365 G_{12}:PR-202 G_{13}:HR-911 G_{14}:VL-315 G_{15}:VR-708, G_{16}: L-5, G_{17}:KMR-204, G_{18}:KMR-301, G_{19}:KMR-340, G_{20}: KMR-630, which are found exclusively in rainfed and irrigated belts were chosen for screening against water stress conditions. The chosen cultivars had different duration ranged from 95 to 130 days. Cultivars with wild relatives are usually considered as tolerance due to genetic reservoirs. There exists a wider diversity among the cultivars for their drought tolerance. Among the cultivars chosen, ML-365 and PR-202 were recognized as drought tolerance against which 18 other cultivars that were subjected to preliminary screening. Two sets of cultivar were sown in line at 30 cm apart in two replications by adopting Randomized Complete Block Design (RCBD). Among the two sets, first set is maintained as control plots without any water stress. In the second set, crop growth was allowed to reach 50 days old i. e., initiation of reproductive stage and then moisture was withdrawn for 15 days (Fig.1.). The relative performance of these cultivars was based on visual and root behavior studies both before and after the imposition of water stress. Based on the results, the following six cultivars having ten days interval were chosen to study in detail. They are KMR-204 and GPU-45 with 95-100 days of duration, GPU-28 and ML-365 with 115 days duration and L-5 and KMR-301 with 125 days duration.

2.1 Agronomic practices

The land was ploughed once with disc plough followed by two harrowing to bring the seedbed to fine tilth. The stubbles and weeds were collected and disposed to facilitate sowing. During layout, small bunds were provided all around each plot and between irrigation channels and the land within each individual plot was leveled manually to maintain uniform irrigation water application. The recommended dose of 50:40:25 N, P_2O_5, K_2O kg ha^{-1} was applied in split dose. NPK was applied in the form of urea, di-ammonium phosphate and muriate of potash, respectively. Half of the recommended dose of nitrogen and full dose of P and K was given as basal dose at the time of transplanting and the remaining 50 per cent N (urea) was provided as top dressing at 35-40 DAS. Irrigation was provided to the control plots (No stress plots) at regular intervals of once in 3 days to maintain the adequate field capacity so as to maintain the crop without any stress. For induction of stress to the plots at reproduction stage moisture was withhold for 15 days. The crop was harvested at maturity as the ear heads turned brownish colour coupled with straw turned to yellowish colour to ground level separately and dried for a week before recording the weight. The grains were cleaned, dried and weight was recorded at less than ten per cent moisture content and finally values were converted to per hectare basis.

Fig.1. Control plots at reproductive stage of 20 finger millet genotypes

duringpreliminary screening

Fig.2. Water stress imposed plots at reproductive stage of 20 finger millet genotypes during preliminary screening

3. RESULTS AND DISCUSSION

For screening, water stress environment was created by withholding the irrigation at reproductive stage for 15 days. The observations were recorded for morpho-physiological, biochemical, yield and yield attributing traits both under control and water stress conditions.

The analysis of variance indicating the source of variation and mean sum of squares for the above characters for the finger millet genotypes tested under control and water stress conditions are presented in Table 1 and 2, respectively. In general, the results indicated highly significant differences among the genotypes for all the traits even at one per cent level of probability (*P<.01*) except harvest index under both control and water stress conditions when analyzed separately for each environment. t- Statistics was also performed to know the effect of stress, data evidenced a significant difference among all the genotypes for all the traits expect harvest index (Table 3). It may reveal a considerable genetic variability amongst the genotypes that are tested.

The shoot length varied significantly from 45.02 to 71.42 cm with a mean of 55.70 cm and 54.62 to 76.25 cm with a mean of 66.90 cm under water stress and control conditions, respectively (Table 3). Significantly highest shoot length was documented in ML-365 (71.42 cm) and lowest in GPU-45 (45.02 cm) under water stress condition. Whereas, significantly highest shoot length of 76.25 cm was unveiled in ML-365 and lowest shoot length of 54.62 cm in GPU-45 under control.

On the similar lines, tested genotypes showed significant difference for root length under both water stress and control conditions (Table 3). In water stress condition, the mean of root length was 312.05 cm as against 273.54 cm in control. The range for this trait under water stress and control conditions was in the array of 203.04 in GPU-45 to 595.58 cm in ML-365 and 185.50 cm in GPU-45 to 439.80 cm in ML-365, respectively.

For root to shoot ratio, the genotypes studied were in the range of 4.28 in MR-6 to 8.34 in ML-365 in water stress condition with a mean of 5.50 whereas, under control condition it was ranged from 3.14 in MR-6 to 5.77 in ML-365 with a mean of 4.03 (Table 3).

Under control condition, the mean leaf area and leaf area index (LAI) was 1240.80 cm^2 $plant^{-1}$ and 4.14 as against 893.63 cm^2 $plant^{-1}$ and 2.98 under water stress condition, respectively (Table 4). Genotype GPU-45 recorded significantly minimum leaf area (888.50 cm^2 $plant^{-1}$) and its index (2.96) while ML-365 recorded significantly maximum leaf area of 1605 cm^2 $plant^{-1}$ with an index value of 5.35. However, under water stress environment, VR-708 documented significantly minimum leaf area (591.50 cm^2 $plant^{-1}$) and LAI (1.97), whereas ML-365 documented significantly maximum leaf area (1383.50 cm^2 $plant^{-1}$) and LAI of 4.61.

Significant difference among the finger millet genotypes for dry matter production was observed with a mean of 17.77 and 12.47 g $plant^{-1}$ under control and water stress conditions, respectively (Table 4). The highest dry matter was recorded in ML-365 (28.00 g $plant^{-1}$) and lowest in GPU-45 (12.60 g $plant^{-1}$) in control condition. On the other hand, lowest dry matter of 8.37 g $plant^{-1}$ was noticed in VR-708 and that of highest in ML-365 (23.38 g $plant^{-1}$) in water stress condition.

The mean relative water content (RWC) in leaves under water stress condition was 60.87 per cent in contrast to 90.26 per cent under control. The range for this trait under water stress and control conditions was in the array of 51.00 per cent in GPU-26 to 74.50 per cent in ML-365 and 84.50 in GPU-26 to 96.50 per cent in ML-365, respectively (Table 5).

In water stress condition, the mean value of membrane stability index (MSI) was 55.81 per cent with a range of 50.00 (GPU-26) to 71.35 (ML-365) per cent. The membrane stability index in control condition was in the range of 82.55 per cent in MR-6 to 94.21 per cent in ML-365 with a mean of 89.21 per cent (Table 5).

Among the 20 genotypes under study, proline content varied significantly and ranged from 21.05 µg g^{-1} FW in GPU-45 to 29.20 µg g^{-1} FW in ML-365 with an average of 24.56 µg g^{-1} FW under control condition. In water stress condition, the mean proline content was 122.60 µg g^{-1} FW with an array of 104.13 µg g^{-1} FW in VR-708 to 153.25 µg g^{-1} FW in ML-365 (Table 5).

The test weight under water stress condition ranged from 2.05 g $plant^{-1}$ to 3.23 g $plant^{-1}$ with the mean of 2.53 g $plant^{-1}$. The significantly highest test weight was recorded in ML-365 (3.23 g $plant^{-1}$) and lowest in KMR-630 (2.05 g $plant^{-1}$). The mean test weight recorded under control was 2.96 g $plant^{-1}$ with a range of 2.58 g $plant^{-1}$ to 3.34 g $plant^{-1}$. The significantly highest test weight of 3.34 g $plant^{-1}$ was observed in ML-365 and lowest test weight of 2.58 g $plant^{-1}$ in GPU-45 (Table 6).

Grain and straw yield showed significant difference among all genotypes for both water stress and control condition. The grain yield under water stress condition was in the range of 20.50 q ha^{-1} (VR 708) to 44.05 q ha^{-1} (ML-365) with the mean of 27.35 q ha^{-1} whereas grain yield under control condition was in the range of 33.50 q ha^{-1} in GPU-45 to 57.05 q ha^{-1} in ML-365 with the mean of 42.94 q ha^{-1}. Further, in water stress condition, the mean of straw yield was 60.23 q ha^{-1} in contrasts to 94.52 q ha^{-1} in control. The range for this trait under water stress and control condition was in the array of 46.30 q ha^{-1} in VR-708 to 90.74 q ha^{-1} in ML-365 and 72.98 q ha^{-1} in GPU-45 to 126.03 in ML-365, respectively (Table 6).

Under water stress situation, the harvest index was ranged from 29.59 per cent in VR-708 to 32.89 per cent in PR-202 with a mean of 31.05 per cent. In control condition, the mean harvest index was 31.34 per cent with the range of 30.17 per cent in HR-911 to 32.68 per cent in PR-202 (Table 6).

3.1 Comparative performance of genotypes under water stress and normal conditions:

The mean values with per cent deviation for morpho- physiological, biochemical, yield and yield components with respect to different finger millet genotypes in test are given in the Table 3 to 6.

Crop plants are highly habitual and acclimatized to different eco-systems. However in its life cycle, it is common to experience drought situation of many kinds yet they have their own protective mechanism to overcome depending on degree of stress and tolerance capacity by individual crop plant. Water stress is a common most factor experienced by the crop during its life cycle.

Among the genotypes tested under water stress situation, the least reduction in shoot length (<10 %) was noticed in two genotypes viz., ML-365 (6.34 %) and PR-202 (8.99 %), while same genotypes recorded enhancement in its root growth to an extent of 35.42 and 29.31 per cent maxima compared to control, which is closely followed by GPU-28 (12.17 and 24.14 %, respectively) (Fig. 3). For shoot length reduction and root length projection, on the other hand, > 20 per cent reduction in shoot length was observed in KMR-630 (23.37 %), GPU-67 (22.33 %), HR-911 (21.92 %) and Indaf-5 (20.54 %) and these genotypes varied from 4.57 to 11.22 per cent in enhancing the root growth. The other twelve genotypes in test had a reduction from 13.07 to 19.81 per cent and enhancement from 4.40 to 20.33 per cent shoot and root growth, respectively (Fig.3). Further, data also indicated the shifting of root to shoot ratio under control (4.03) to water stress (5.50) activity with increment by 36.15 per cent, thereby showing strong evidences for allometric partitioning of photosynthates, indicating importance of root growth under water stress [9 & 10]. Presented values of leaf area of 20 genotypes tested varied from 13.80 to 39.91 per cent reduction under water stressed environment. The leaf area index value essentially followed the trend to that of leaf area. Generally, reduction in the leaf area under stress environment attributed to less number of leaf production along with their size. The expansion of the leaf normally depends upon the turgor pressure and the supply of assimilates. Reduced turgor pressure and slow rate of photosynthesis under drought conditions mainly limit the leaf expansions [11]. The variation presented and discussed in the above parameters truly contributed to cause variations in an ultimate carbon sink *i.e*., dry matter and as well economic yield. Accordingly, imposition of water stress decreased the shoot dry weight (16.49 to 41.74 %) and yield (22.79 to 49.05 %) considerably. One of the effective mechanisms of drought tolerance in crops is to utilize accumulated photosynthates in the stem for grain filling [12]. Water stress that reduces plant water status and photosynthesis during grain filling induces the conversion of stem storage into soluble sugars and the mobilization of sugars into grains [13].

The soil plant water continuum is lost due to shortage of water supply. To manage these ad hoc situations, plants adjust relative water content without much scarification of physiological activities. Membrane stability is a widely used criterion to assess crop drought tolerance, since water deficit causes water loss from plant tissues and induces the oxidative stress due to increased production of reactive oxygen species, especially in photosynthetic organelles. This could directly oxidize the lipid membranes so its permeability increases and cause ion leakage and membrane injury [14 & 15] and there by reduces the MSI. Further, the induced activity of proline related mechanism and plants resistance to stress conditions [16] were well established fact.

4. CONCLUSION

Screening of genotypes under water stress condition helps to select desirable genotypes,which survive better and provides a key role in success of crop improvement programmes. From the present investigation, among the 20 genotypes tested, KMR-204 and GPU-45 in short duration, ML-365, PR-202 and GPU-28 in medium duration, KMR-301 and L-5 in long duration showed identical performance for maximum number of traits under consideration and hence carry forwarded for field studies.

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Table 1. Analysis of variance for drought related characters of finger millet genotypes under control (non-stress) condition

Source of variance	d.f.	SL	RL	R/S	LA	LAI	SDW	RWC	MSI	PRO	TW	GY	SY	HI
Replication	1	72.77	1051.65	0.10	390.63	0.004	2.30	4.62	0.43	0.81	0.01	4.36	0.40	2.56
Genotypes	19	103.65**	13117.54**	1.34**	96111.71**	1.068**	37.30**	22.07**	16.97**	17.51**	0.11**	106.71**	656.45**	0.86^{NS}
Error	19	18.27	824.97	0.11	11976.89	0.133	3.59	5.89	3.87	3.76	0.04	7.51	57.68	1.25
S. Em ±		3.02	20.31	0.23	77.39	0.26	1.34	1.72	1.39	1.37	0.14	1.94	5.37	0.79
CD @ 5 %		8.95	60.12	0.69	229.06	0.76	3.97	5.08	4.12	4.06	0.43	5.74	15.90	2.34
CD @ 1 %		12.23	82.17	0.94	313.10	1.04	5.42	6.95	5.63	5.55	0.58	7.84	21.73	3.20

Table 2. Analysis of variance for drought related charactersoffinger millet genotypes under stress condition

Source of variance	d.f.	SL	RL	R/S	LA	LAI	DM	RWC	MSI	PRO	TW	GY	SY	HI
Replication	1	90.00	2250.00	0.90	2656.90	0.03	2.50	2.40	14.88	47.42	0.01	2.40	32.54	9.90
Genotypes	19	91.42**	21694.32**	3.11**	84138.14**	0.93**	28.11**	82.19**	82.00**	362.03**	0.25**	73.04**	284.30**	1.71^{NS}
Error	19	26.84	523.68	0.27	5606.54	0.06	0.61	9.71	8.95	34.98	0.03	6.18	33.51	10.01
S. Em ±		3.66	16.18	0.37	52.95	0.18	0.55	2.20	2.12	4.18	0.12	1.76	4.09	2.24
CD @ 5 %		10.84	47.90	1.08	156.72	0.52	1.63	6.52	2.86	12.38	0.37	5.20	12.12	6.62
CD @ 1 %		14.82	65.47	1.48	214.22	0.71	2.23	8.92	8.56	16.92	0.50	7.11	16.56	9.05

Where, *- Significant @ 5 %, **- Significant @ 1 %, NS- Non significant

Note:

SL- Shoot length (cm)	LA- Leaf area (cm^2)	RWC- Relative water content (%)	TW- Test weight (g)	HI- Harvest index (%)
RL- Root length (cm)	LAI- Leaf area index	MSI- Membrane stability index (%)	GY- Grain yield (q ha^{-1})	
R/S- Root to shoot ratio by length	SDM-Shoot dry weight (g $plant^{-1}$)	PRO- Proline (µg g^{-1} FW)	SY-Straw yield (q ha^{-1})	

Table 3. Comparative performance of finger millet genotypes under water stress and normal conditions

Genotypes	Shoot length (cm)			Root length (cm)			Root to Shoot ratio by length		
	Control	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**

GPU-26	56.38	45.21	19.81	206.50	215.60	-4.40	3.67	4.77	-30.19
GPU-45	54.62	45.02	17.58	185.50	203.04	-9.46	3.40	4.51	-32.80
GPU-48	57.78	46.80	19.00	210.00	220.16	-4.84	3.63	4.70	-29.43
VR-708	58.95	48.16	18.30	194.00	207.86	-7.14	3.29	4.32	-31.17
KMR-340	72.35	59.54	17.70	263.15	280.79	-6.71	3.64	4.72	-29.58
KMR-204	58.50	49.18	15.92	211.60	237.68	-12.32	3.62	4.83	-33.61
GPU-28	70.80	62.18	12.17	312.85	388.36	-24.14	4.42	6.25	-41.33
GPU-66	68.65	57.31	16.53	242.50	277.90	-14.60	3.53	4.85	-37.26
INDAF-5	74.39	59.11	20.54	412.50	458.78	-11.22	5.55	7.76	-39.97
ML-365	76.25	71.42	6.34	439.80	595.58	-35.42	5.77	8.34	-44.58
PR-202	58.56	53.30	8.99	190.00	245.69	-29.31	3.24	4.61	-42.06
HR-911	74.78	58.38	21.92	415.50	451.37	-8.63	5.56	7.73	-39.12
VL-315	61.94	50.83	17.92	197.00	221.54	-12.46	3.18	4.36	-37.02
GPU-67	72.70	56.47	22.33	330.00	351.10	-6.40	4.54	6.22	-36.98
INDAF-7	69.57	60.00	13.75	244.50	278.57	-13.93	3.51	4.64	-32.09
MR-1	71.80	58.66	18.30	313.00	350.51	-11.99	4.36	5.98	-37.07
MR-6	64.83	53.69	17.18	203.50	229.65	-12.85	3.14	4.28	-36.26
L-5	68.10	58.55	14.02	254.85	301.64	-18.36	3.74	5.15	-37.64
KMR-301	73.75	64.11	13.07	328.00	394.67	-20.33	4.45	6.16	-38.40
KMR-630	73.30	56.17	23.37	316.00	330.43	-4.57	4.31	5.88	-36.40
Mean	**66.90**	**55.70**	**16.74**	**273.54**	**312.05**	**-13.45**	**4.03**	**5.50**	**-36.15**
t- statistics	**15.16****			**-5.19****			**-14.96****		

Note: ** - Significance @ 1 %, NS- Non significant

Table 4. Comparative performance of finger millet genotypes under water stress and normal conditions

Genotypes	Leaf area (cm^2 $plant^{-1}$)			Leaf area index			Shoot dry weight (g $plant^{-1}$)		
	Control	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**
GPU-26	1184.00	722.00	39.02	3.95	2.41	39.02	14.40	8.58	40.41
GPU-45	888.50	595.50	32.98	2.96	1.99	32.98	12.60	8.54	32.21
GPU-48	1155.00	715.50	38.05	3.85	2.39	38.05	14.70	9.00	38.76
VR-708	954.00	591.50	38.00	3.18	1.97	38.00	13.35	8.37	37.33
KMR-340	1343.00	915.00	31.87	4.48	3.05	31.87	17.20	11.51	33.06
KMR-204	1171.50	876.00	25.22	3.91	2.92	25.22	15.80	11.59	26.68

GPU-28	1288.50	1078.00	16.34	4.30	3.59	16.34	17.50	14.02	19.87
GPU-66	1176.50	848.50	27.88	3.92	2.83	27.88	16.35	11.76	28.06
INDAF-5	1507.00	1140.00	24.35	5.02	3.80	24.35	21.80	14.06	35.53
ML-365	1605.00	1383.50	13.80	5.35	4.61	13.80	28.00	23.38	16.49
PR-202	956.00	804.25	15.87	3.19	2.68	15.87	12.90	10.50	18.62
HR-911	1551.50	1035.00	33.29	5.17	3.45	33.29	13.90	9.80	29.50
VL-315	956.00	667.50	30.18	3.19	2.23	30.18	13.45	8.89	33.93
GPU-67	1470.50	933.50	36.52	4.90	3.11	36.52	19.55	12.16	37.80
INDAF-7	1113.50	843.50	24.25	3.71	2.81	24.25	16.75	12.42	25.85
MR-1	1381.50	973.00	29.57	4.61	3.24	29.57	19.35	13.52	30.11
MR-6	1017.00	727.00	28.52	3.39	2.42	28.52	25.00	16.32	34.72
L-5 (G6)	1238.00	977.50	21.04	4.13	3.26	21.04	18.35	14.21	22.56
KMR-301	1462.00	1206.25	17.49	4.87	4.02	17.49	23.60	18.67	20.87
KMR-630	1397.00	839.50	39.91	4.66	2.80	39.91	20.85	12.15	41.74
Mean	**1240.80**	**893.63**	**28.21**	**4.14**	**2.98**	**28.21**	**17.77**	**12.47**	**30.20**
t- statistics	**13.56****			**13.60****			**14.04****		

Note: ** - Significance @ 1 %, NS- Non significant

Table 5. Comparative performance of finger millet genotypes under water stress and normal conditions

Genotypes	Relative water content (%)			Membrane stability index (%)			Proline (µg g^{-1} FW)		
	Control	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**
GPU-26	84.50	51.00	39.64	83.78	50.00	40.32	22.25	107.90	-128.36
GPU-45	86.50	55.90	35.38	86.70	54.00	37.72	21.05	112.75	-144.84
GPU-48	87.80	53.75	38.78	87.85	50.50	42.52	22.10	104.50	-121.87
VR-708	86.95	53.75	38.18	86.95	50.50	41.92	21.75	104.13	-122.73
KMR-340	87.05	55.00	36.82	90.38	51.50	43.02	22.30	110.60	-133.83
KMR-204	89.50	59.50	33.52	88.30	56.50	36.01	21.85	116.50	-148.67
GPU-28	94.34	68.50	27.39	90.50	66.50	26.52	28.15	145.00	-172.81
GPU-66	89.60	60.50	32.48	89.40	53.00	40.72	27.20	127.75	-144.73
INDAF-5	90.15	63.00	30.12	91.00	52.50	42.31	28.50	128.20	-139.63
ML-365	96.50	74.50	22.80	94.21	71.35	24.26	29.20	153.25	-182.75
PR-202	95.40	72.00	24.53	93.00	66.00	29.03	26.55	144.00	-179.34
HR-911	93.90	65.00	30.78	88.50	52.35	40.85	28.95	130.15	-141.24
VL-315	86.80	56.50	34.91	86.80	51.50	40.67	26.95	126.40	-143.31

GPU-67	91.70	64.00	30.21	90.50	52.50	41.99	28.15	125.50	-136.12
INDAF-7	89.31	59.50	33.37	89.51	57.00	36.32	22.05	117.05	-148.78
MR-1	91.10	61.50	32.49	89.50	52.00	41.90	22.95	116.55	-143.07
MR-6	87.35	57.00	34.75	82.55	52.00	37.01	21.60	114.05	-144.74
L-5	91.10	64.50	29.20	91.10	60.50	33.59	22.60	123.25	-158.93
KMR-301	93.25	67.00	28.15	92.85	64.50	30.53	23.70	129.25	-165.40
KMR-630	92.50	55.00	40.54	90.85	51.50	43.31	23.40	115.25	-138.12
Mean	**90.26**	**60.87**	**32.70**	**89.21**	**55.81**	**37.53**	**24.56**	**122.60**	**-146.96**
t- statistics	**35.62****			**30.34****			**-39.17****		

Note: ** - Significance @ 1 %, NS- Non significant

Table 6. Comparative performance of finger millet genotypes under water stress and normal conditions

Genotypes	Test weight (g plant^{-1})			Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Harvest Index (%)		
	Control	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**	**Control**	**Stress**	**Change in % mean**
GPU-26	2.65	2.08	21.70	37.65	21.20	43.69	83.01	48.97	41.01	31.29	30.21	3.44
GPU-45	2.58	2.23	13.59	33.50	20.60	38.51	72.98	47.17	35.36	31.48	30.40	3.46
GPU-48	2.69	2.15	20.26	37.75	21.65	42.65	83.26	50.23	39.67	31.29	30.12	3.75
VR-708	2.77	2.24	19.13	35.00	20.50	41.43	77.54	46.30	40.29	31.13	29.59	4.97
KMR-340	2.82	2.33	17.41	42.40	25.90	38.92	93.24	57.66	38.16	31.25	30.96	0.94
KMR-204	3.10	2.72	12.42	38.20	25.00	34.55	81.04	54.25	33.06	32.06	31.55	1.60
GPU-28	3.20	2.98	7.03	42.45	30.40	28.39	88.78	62.02	30.15	32.37	32.64	-0.83
GPU-66	3.08	2.65	13.82	41.45	26.35	36.43	91.18	59.55	34.69	31.31	30.67	2.03
INDAF-5	2.80	2.28	18.75	51.15	30.85	39.69	117.30	69.41	40.82	30.35	30.77	-1.37
ML-365	3.34	3.23	3.30	57.05	44.05	22.79	126.03	90.74	28.00	31.27	32.68	-4.52
PR-202	3.31	3.13	5.45	34.30	26.00	24.20	70.64	53.04	24.91	32.68	32.89	-0.65
HR-911	2.86	2.34	18.18	51.70	31.50	39.07	119.78	71.51	40.30	30.17	30.58	-1.36
VL-315	2.98	2.53	14.96	35.00	22.10	36.86	74.99	49.28	34.28	31.82	30.96	2.70
GPU-67	2.74	2.20	19.56	47.05	27.55	41.45	106.14	61.71	41.86	30.72	30.86	-0.46
INDAF-7	3.13	2.74	12.32	41.90	27.65	34.01	90.68	60.28	33.53	31.60	31.45	0.47
MR-1	2.91	2.45	15.81	44.20	27.50	37.78	97.20	61.05	37.19	31.25	31.06	0.63
MR-6	3.05	2.62	14.26	37.40	23.65	36.76	80.91	53.16	34.30	31.59	30.40	3.79
L-5	3.17	2.80	11.53	43.70	29.35	32.84	92.89	62.13	33.12	32.00	32.15	-0.48
KMR-301	3.23	2.93	9.30	57.15	39.75	30.45	128.56	86.55	32.68	30.85	31.02	-0.57

KMR-630	2.70	2.05	24.07	49.85	25.40	49.05	114.32	59.57	47.89	30.36	30.05	1.02
Mean	**2.96**	**2.53**	**14.64**	**42.94**	**27.35**	**36.48**	**94.52**	**60.23**	**36.06**	**31.34**	**31.05**	**0.93**
t- statistics	**13.65****			**19.45****			**16.75****			**1.80**^{NS}		

Note: ** - Significance @ 1 %, NS- Non significant

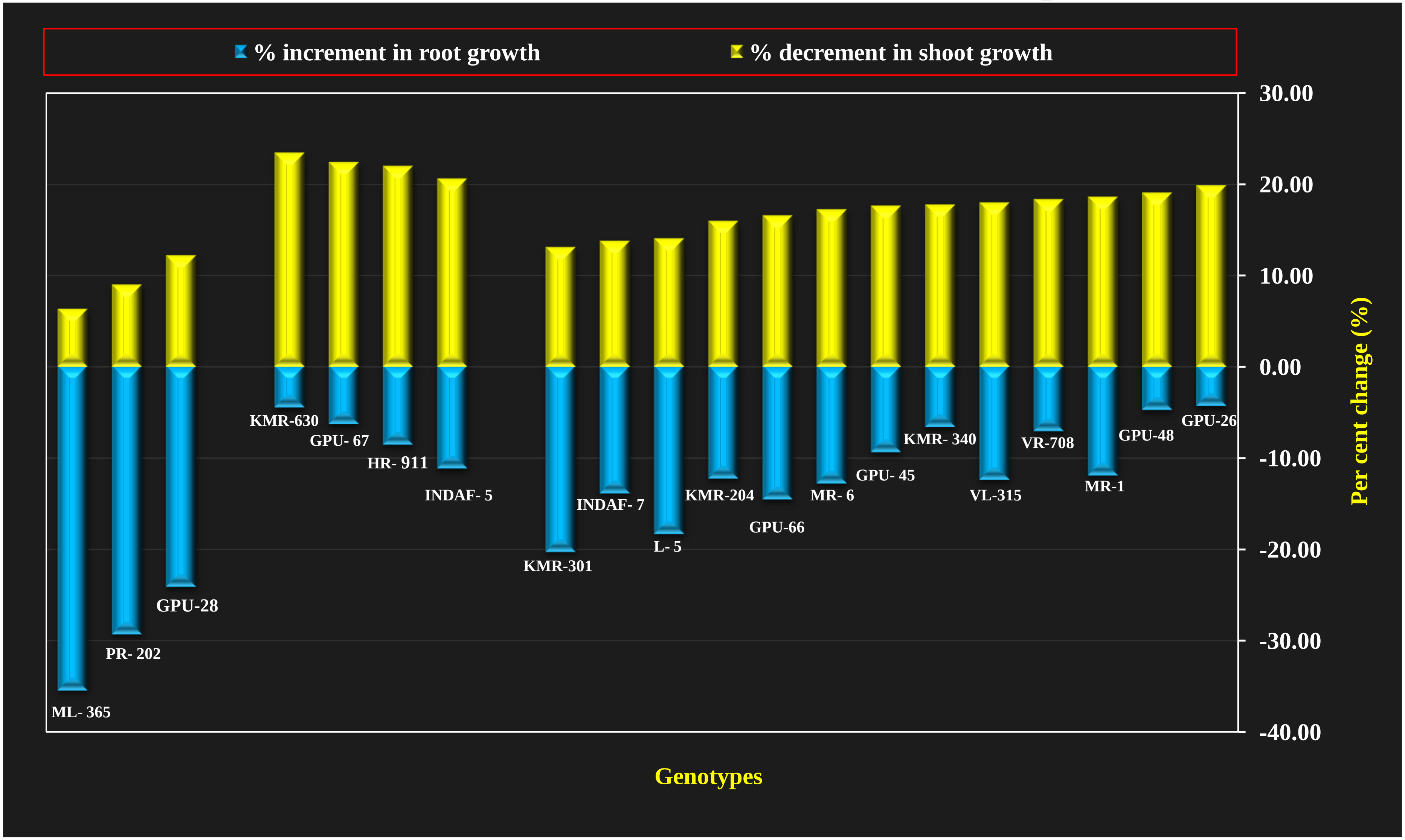

Fig.3. Per cent change in mean root and shoot length offinger millet genotypes under stress and control condition